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THE MONTANA STATE BOARD
OF ENTOMOLOGY

THIRD
BIENNIAL REPORT

1917-1918

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STATE BOARD
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1917-1918

JANUARY 1919

MONTANA STATE BOARD OF ENTOMOLOGY.

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Secretary - - - - - Bozeman, Montana

R. R. Parker, Ph. D. - - - - - Bozeman, Montana
Assistant Entomologist.

LETTER OF TRANSMITTAL

Bozeman, Mont., Dec. 15, 1918.

To His Excellency,
Governor S. V. Stewart,
Helena, Montana.

My Dear Sir:

In behalf of the State Board of Entomology I have the honor to transmit to you the Third Biennial Report.

There are reasonable prospects that the danger from the wood tick in the northern portion of the Ravalli County district can be eliminated during the next two seasons in so far as land in the valley itself is concerned. Progress in the southern areas has not been so satisfactory, however, and a longer time will doubtless be required to make conditions safe. Once the farm land in the valley and the adjoining foothill country has been cleaned up, however, there still remains the question of permanent safety which involves the need for further research and for probable control efforts within the mountainous area west of the present control districts.

Very respectfully yours,
R. A. COOLEY,
Secretary.



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Third Biennial Report of the Montana State Board of Entomology

By R. A. COOLEY, Secretary.

During the biennium now closing the activities of the Montana State Board of Entomology have been devoted almost entirely to the investigation and eradication of the spotted fever tick. In the season of 1917 the intensive control work under way in the Bitter Root valley was being continued, as previously, under a plan of cooperation between the U. S. Public Health Service, the U. S. Bureau of Entomology, and the State Board of Entomology. Dr. L. D. Fricks, representing the Public Health Service, and Dr. W. V. King, representing the Bureau of Entomology, were again in the valley and in charge of the eradication work, the former in the southern portion of the valley with headquarters in Victor and the latter in the northern part with headquarters in Florence. At the close of the season of 1917 the Public Health Service withdrew and closed up their work. It was expected at the time that the Bureau of Entomology would continue, but some months later, after Dr. King had completed his work for the season and had gone to his other work elsewhere, for the remainder of the year, the Bureau decided to withdraw also. This left the State without outside assistance in the eradication work.

Following the appearance of a surprisingly large number of cases of spotted fever in a number of counties in eastern Montana in 1915, a research Station was established at Powderville, Custer County in the early spring of 1916 and Dr. R. R. Parker, Assistant Entomologist, was placed in charge. The results of the studies conducted in this Station were discussed in the last report of this Board. In 1917 this field Station was moved to Musselshell, in Musselshell County, and Dr. Parker continues his studies there. Important results were secured and are presented as a part of this report in a paper by Dr. Parker. With the assistance from the federal government removed it was

necessary in 1918 for the Board of Entomology to take over the entire control work in the Bitter Root valley and the work at the Musselshell station was discontinued.

Control Methods in Use

Dr. Parker was placed in charge of the control work in the Bitter Root valley in the spring of 1918 and established his headquarters at Victor on March first. Whereas Drs. King and Fricks each had one-half of the valley in charge in the control work, Dr. Parker was responsible for the entire valley and his territory extended from Lost Horse Creek on the south nearly to Carlton on the north, a distance of 38 miles. Outside of this, important work was also done in the O'Brien Creek country still 20 miles farther north. Our funds being limited to \$5,000 while the two government agencies were backed up with very much larger sums, further increased the difficulties which the Board of Entomology had to encounter. However, these difficulties were all foreseen and the Board took steps to engage the fuller cooperation of the residents. It was very evident that we would not be able to relieve the residents of as much of the actual work of eradication as the Federal Government had done. Our purpose in the season's work was, therefore, to use our limited funds to the best advantage possible in making sure that none of the good results previously gained were lost and, further, to lay definite and final plans for the future conduct of the eradication work. Before the opening of spring the entire Board toured the valley, making stops at Hamilton, Victor, Stevensville and Florence and held meetings with the residents explaining the necessary changes in the control program.

Control Methods in Use

The various control methods in use are based on our researches and on the experiences of the two government agencies that have been doing the actual control work, with such modifications as have seemed advisable. They are the following:

1. Ground squirrel destruction.
2. Control of grazing on tick infested areas
3. Dipping and otherwise freeing domestic animals of ticks.

The control methods are carefully adjusted to the habits and life history of the tick, an understanding of which is necessary in order to comprehend the reasons for adopting the particular methods. The tick feeds on the blood of mammals and has no other source of food although it is quite possible that water is taken through the mouth. The adult ticks, male and female, attach to the skin of the larger animals, the horse and cow and sheep being favorites among domestic animals, though the dog and hog are also attacked. Among the larger wild animals the bear, coyote, badger, jack rabbit, snow shoe rabbit and wood-chuck are attacked to some extent. However, these animals are not abundant and are so little used as hosts that they are of but little importance from a practical standpoint. The mountain goat deserves special mention because it feeds ticks in great abundance and, well back in the mountains, is a common animal. So far as valley conditions are concerned in our eradication program the goat may be overlooked but if we are later to take up eradication work back in the mountains this animal will certainly need attention. While on the host the sexes mate and the female becomes greatly distended with feeding. When fully engorged the female drops to the ground and lays several thousand eggs, which hatch into minute larval or "seed" ticks. These crawl up on dead grass or other supports and wait for some small mammal or rodent to pass within reach. When the opportunity comes these very minute parasites pass to the host and, crawling into the hairs, attach to the skin, many often feeding upon the small animal. The rodents most used as hosts of the seeds are the ground squirrel, chipmunk and pine squirrel. Of these the ground squirrel is very much more abundant than any of the others, and it is quite clear that this animal, which is also very objectionable because it destroys crops, is responsible for feeding a very large proportion of the seed ticks in the Bitter Root valley.

The seeds fill up with blood and drop to the ground where they go through a quiescent period during which the seed transforms to the middle-sized tick or nymph, which is flat and hungry as were the seeds and like them crawls up and waits on supports for the passing of suitable hosts.

The same list of animals is used as hosts as in the case of the seeds and again the ground squirrel is by far the most important animal.

To summarize the foregoing, the adult ticks feed on large domestic animals, mainly, though certain large wild animals serve as hosts also but are of much less importance because less used and much less abundant. Both seeds and nymphs feed mainly on the ground squirrel.

It follows that if the tick can be prevented from feeding as an adult on domestic animals, principally horses and cows, and as seeds and nymphs on the ground squirrel, a very high efficiency in tick eradication will follow. The question of the necessity of preventing feeding of adults on other domestic animals and on the larger wild mammals, and of seeds and nymphs on other rodents, naturally arises. It could be shown from the records accumulated in the Bitter Root valley through some ten years that these other sources of tick population are of minor, if not negligible, importance.

When intensive control work was commenced in 1913 it was believed that the dipping of horses and cattle and otherwise keeping these animals free of adult ticks would be the most effective control method; indeed, it was felt that if this one method could be very thoroughly carried out and all domestic animals, including those in pastures and on the range, could be kept free of ticks, no other method would be needed. This was based on the knowledge that the adult ticks, which alone are able to reproduce the species, feed only on the large animals and can reproduce only after feeding. It has developed, however, that the dipping alone is not sufficient because, on account of the cold rainy weather in the spring it cannot be systematically done. It was quite impossible also at times to find and deliver at the dipping vats at reasonable expense all of the stock that was grazing in large, brushy pastures and on the range. The dipping when done was effective and grew to be popular among the residents because of the destruction of ticks and also because the condition of the animals was improved.

Because of the necessary irregularity of the dipping and because a considerable number of animals escaped

even when regular dipping was possible, resulting in the dropping of engorged female ticks, it was found advisable to give more attention to other means of control.

We naturally turned to ground squirrel killing since, as has been pointed out above, these rodents serve to produce by far the greater part of fed seeds and nymphs without which the species cannot continue. The farmers joined the more readily in the squirrel killing as it was recognized that the destruction of these animals would result in a great saving of crops. Squirrel destruction has been carried on almost from the first and was indeed practiced by Dr. McClintic when he was located at Victor in 1911. The methods have been gradually improved with experience.

Recognizing that while it was difficult to effectively dip horses and cows it was yet very desirable to prevent adult ticks from feeding on these animals and dropping as engorged ticks ready to lay eggs, steps were taken to prevent as far as possible the grazing of such animals in tick infested areas. A program of grazing control was therefore adopted and owners were urged to avoid the continuance of conditions that allowed ticks to feed. Arrangements were made through the courtesy of the Forest Reserve offices in Missoula for the removal of many animals from the tick districts to grazing areas in the forest reserve. In other instances owners were induced to avoid turning animals into the pastures until after the tick season was over, holding them instead in tick free or squirrel free areas.

The squirrel destruction and grazing control have continued with good results and dipping under favorable conditions has also been in favor with the residents and will continue in the future along with the other methods.

Certain supplementary methods of control should be mentioned. The conditions which have favored the continuance and multiplication of ticks are the giving over of the land to pasturage, with squirrels, livestock and brush, present in abundance. The desirable conditions are having the land under cultivation with good fences, preferably of wire, clean fence corners and roadsides, no ground squirrels, and for the present no livestock. With such conditions prevailing there could be no tick problem in the Bitter Root

valley. With either no squirrels or no livestock the ticks could not continue but with these two present and no brush there could be ticks in abundance. Some measure of protection such as is afforded by dead grass in the spring is doubtless necessary for the continued abundance of ticks, but brush probably is not necessary and the clearing and burning of brush in itself is secondary value. It is of value in the sense that it is a necessary preliminary to the slicking up of the land and placing it in cultivation. Some residents have resorted to the burning over of the land as a means of eradication, thinking that the ticks could not withstand the fire. Certainly, ticks that are touched by fire are killed but it must be borne in mind that the ticks do not remain up on the grass all of the time but spend a part of the time on or in the ground. Also, it must be remembered that the ticks are more abundant out in the little parks and grassy areas than in the more brushy spots where the fire will spread readily. The facts are that we have plenty of evidence to show that the ticks have continued year after year in areas that have been burned over. Some ticks doubtless are killed by the fire but others are left and with stock and squirrels present these will increase and continue the spotted fever menace.

Results

Now that the work of eradication has continued for six years it is only natural to pause and ask: What results have been obtained? The more important results are the following:

1. There are fewer cases of spotted fever than formerly.
 2. There are fewer ticks than formerly.
 3. The residents are better informed regarding the real cause of the disease and ways of avoiding it than before.
 4. Based on good, substantial reasons the residents, both on the farms and in the towns, have a greater confidence in the future of the valley.
 5. There is less apprehension concerning the disease.
- Owing to a measure of indefiniteness in the diagnosis of spotted fever in earlier years it is impossible to give very definite figures on the number of cases that formerly

occurred. In the more recent years, and yet before our control work began, due largely to the efforts of Dr. Ricketts, the disease was more positively recognized and we know that the cases ran about eight to twelve per year. The number was never much lower than this but at times it was higher. In 1909, the year in which there were many men on railroad construction work up the Lo Lo Canyon there were twenty-eight cases. It is of much interest, therefore, to compare these figures with those covering the six years since the Board of Entomology has been in existence.

Spotted Fever Cases in Recent Years in the Bitter Root Valley

	Ravalli County	Missoula County	Total
1913	---	---	11
1914	6	4	10
1915	3	5	8
1916	5	1	6
1917	5	1	6
1918	2	1	3

Information for this table has been furnished us by Dr. Cogswell, Secretary of the State Board of Health. None of the cases in 1918 were in any of the districts where control work has been carried on.

It is very expensive to get entirely reliable data regarding the actual abundance of ticks in any given territory. An attempt to get such data was made by Dr. King and I can do no better than to quote from his report. (Page 19, Second Biennial Report, State Board of Entomology, 1917).

“Results of Control Work”

“In estimating the effect of the control measure in the reduction of ticks, several methods are employed. Unfortunately all of these are open to more or less criticism. The most promising method is one in which an index of the seasonal rate of infestation of ground squirrels is obtained and used for comparison. A series of these rodents from the tick infested area are killed (by shooting) and immediately placed in white muslin bags. The ends of the bags are tied to prevent escape of the ticks and the examination is made several hours later. By this time the larval or nymphal ticks have

detached and are found crawling on the bag or in the hair of the dead animal.

In the following table is shown the infestation rate for three seasons:

Nymphal Infestation

Year	No. Squirrels	No. Nymphs	No. Nymphs per Squirrel	Reduction from Normal	1915
Normal	181	863	4.76		
1915	333	232	.069	85.6%	
1916	376	159	0.42	91.3%	39.3%

Larval Infestation

Year	No. Larvae	No. Larvae per Squirrel		
Normal	59	735	12.4	
1915	269	312	1.16	90.7%
1916	268	25	0.093	99.7% 92%

The "normal" is based on a series of squirrels examined in 1910. The most interesting comparison is found in the average nymphal infestation in 1915 and '16, as exactly the same area was covered in each season. The 1910 records were made in a portion of this area. The larvae commence to appear on the squirrels the latter part of June and the average infestation is taken from the squirrels examined after the first larvae are found. The examination of squirrels is of further value in showing the exact points in which development of ticks is occurring.

The average infestation of domestic animals with adult ticks and the proportion of engorged ticks present is also employed as a method of estimating results, but is not of great value. Such data as are at hand are shown below. The number of engorged females per animals (per day) as given in the last column, are used for comparison.

Infestation of Cattle and Horses

Year	Total No. Animals	No. Ticks	No. Eng'd Females	No. Ticks per Animal	No. Eng'd Fem. per Animal
Normal	235	289	8	1.23	.034
1914	1720	622	11	.36	.0063
1915	*1793	728	18	.4	.01
1916	1024	1648	9	1.6	.0087

The normal records were made in 1914 in a nearby locality in which conditions were similar to those in the control district. The data for the different years are not strictly

*The number of ticks not counted on 60 other animals examined.

comparable, since it is not possible to examine animals under the same conditions and with the same frequency each season. In 1916 it appears that the average number of ticks per animal for the whole district is greatly increased. As a matter of fact, this is due to the fact that a few animals in a small but heavily infested portion of the district were frequently hand-picked instead of dipped, as in previous years.

A third method of estimating results is the collection of unfed adults from the infested fields by dragging a piece of white flannel cloth about over the grass and brush where the ticks are awaiting hosts. Several factors such as wind, temperature, and time of season operate against the effectiveness of this method and the results are hardly comparative.

In 1915 and '16 records were kept of the number of ticks picked up by the squirrel poisoners. These figures are more or less comparable, as the number of men, area covered and time of year were practically the same.

Ticks Collected by Squirrel Poisoners

Year	Period	Number Man—Day	Total Ticks	Ticks Per Man—Day	Mean. Temp.
1915	April 6 to 17	132	758	5.74	53°F.
1916	April 8 to 17	126	372	2.95	45°F.

It was indicated by this comparison that in 1916 the density of ticks had been reduced 48 per cent from the precious year. This was as great, in fact a slightly greater reduction than was to be expected from the 1915 record of the status of nymphal infestation of ground squirrels.

In interpreting the results, the complicated life history of the tick must be taken into consideration. Our studies have shown that under western Montana conditions this species has a two- and three-year life cycle. A reduction of the number of ticks engorged in any spring would result in an equal reduction of the larval ticks fed in the summer and of the nymphal ticks feeding the second spring, but would effect only a half of the active adults present during the third and fourth season, since the active adults are made up of two separate broods probably in nearly equal numbers. For example, a reduction of 85 per cent of engorged females in both 1914 and '15 should give a reduction of 42 per cent of active adults in 1916 and an 85 per

cent reduction in 1917. The destruction of rodents is considered to effect the abundance of ticks in direct ratio to the percentage of rodents killed. The nymphal infestation of ground squirrels in 1915, combined with the estimated reduction of these animals, indicated an approximate reduction of 92 per cent of that brood of adults and a proportionate (46%) reduction of the total adult supply for 1916. Interpreting the nymphal index for both 1915 and '16 in the same way, a 94 per cent reduction of active adults is indicated for 1917."

The foregoing quotation does not cover the last two-year period and we have only the opinions of citizens to go by. Dr. Parker is going back and forth among the residents was told many times, and in very convincing ways, that the ticks are much less abundant than formerly. One man near Florence whose hand is well back toward the mountains said that during the season of 1918 he had seen only one or two ticks and these came from close in to the edge of the mountains. This man's land was formerly in the heart of one of the most ticky districts.

It should be stated that much better results have been obtained in some localities than in others and this has been due in a very large measure to the more effective cooperation of the residents in certain localities. Some localities already have been placed outside of the control districts by action of the Board because there are no ticks present, and certain other localities are under consideration for removal from the districts. It has been, and will continue to be, the policy of the Board to release new territory as fast as it becomes free of ticks.

To show the opinions of residents regarding the present abundance of ticks and the improved conditions generally several letters from residents are attached.

Victor, Montana, Dec. 27, 1918.

Prof. R. A. Cooley,
Secy. of the State Board of Entomology,
Bozeman, Montana.

Dear Sir:

I am informed that we have only an appropriation of \$5000 to carry on the wood tick control for the coming season and, in my opinion, that is entirely inadequate for the successful control of the wood tick work.

The work that has been done has greatly increased the value of lands in this district, and has caused the residents to feel that the danger has been very greatly reduced by the work which has been done here and all are heart in hand with the continuance of the good work, and I kindly ask you, in behalf of the residents of this vicinity, to try to get at least as much more money appropriated for this work, making at least \$10,000, as it will be used to the best advantage by the faithful workers along this line.

Yours very truly,
H. J. ST. JOHN.

Florence, Montana, Dec. 28th, 1918.

Dear Sir:

I am writing you at this time to see if, in your opinion, there cannot be something done to have the appropriation for "tick control" increased at this session of the legislature.

It seems really too bad that the work cannot be carried on for a few years longer when we are so near "over the top."

I hear so much from parties living along the mountains of there being so few ticks and the seeming decrease in the number of gophers, that it looks as though we might, with a good strong pull for another year or two completely exterminate the tick and possibly the gopher, too.

To prove to you that the number of ticks has diminished to a very great extent will say that three other men and myself spent a half day putting out squirrel poison on the tract of land where you had the "Tick Camp," at a time when the ticks are generally the worst, and we did not see a tick, and only saw two or three gophers. Both you and Dr. King have told me that that tract was about the worst infested place around here.

Naturally the residents feel that the danger is largely eliminated, which is true, but it is not entirely eliminated, and I am afraid that it will not only result in the people relaxing their efforts to entirely get rid of the ticks, but possibly endanger their lives through carelessness, unless we have a leader to keep the proposition going.

You would naturally think that the conditions would have some effect on land values in the control district, and I believe they have, but owing to war conditions there is no land changing hands, but it is easy to see that when a piece of land in this district is on the market it has some show. We no longer hear the remark, "I wouldn't have it and live on it if they would give it to me—it's in the Spotted Fever District."

I think the residents were just beginning to realize that your methods were doing a whole lot of good, and were beginning to cooperate with you, and I believe that you can get them to do almost anything you reasonably ask, which you know has not been the case heretofore, to finish the job up right.

I hope you can put this proposition up to the legislators in such a way that they will see how necessary it is that this great work should be carried on to completion.

If there is any way that I can help in this matter, don't fail to call on me.

Yours very truly,
ARTHUR HERBERT.

Stevensville, Mont., Jan. 2, 1919.

Dear Sir:

Will write you in regard to the tick work in the Bitter Root, will say:

First: The ticks have been reduced in some places to almost nothing and others to one-half of their former numbers. Where I live it is almost impossible to find a tick.

Second: The residents of the district have felt the result of the work as they realize the fever is not anywhere near as bad as before the work began.

Third: The result has been an increase in land values, as it was most impossible to sell land before the work began, but now land sells as readily as it does on east side of river.

Fourth: Most all of the residents are in favor of the control work as they can see that it has reduced the fever. Of course, there are some sore heads who will never say anything does any good.

As far as I am concerned I would like to see a law passed to compel all land owners to poison ground squirrels and if they will not, to have it done for them and charge it to their taxes, as I believe the squirrels have more to do with the ticks than any other animal, and I believe if we could get rid of them we could soon get rid of the ticks.

Yours truly for better control of the ticks,
(Signed) T. M. COUCH

Missoula, Mont., Jan. 4, 1919.

Dear Sir:

I notice there has been only a \$5000 appropriation given the State Board of Entomology for the continuation of work for the eradication of ticks in the Bitter Root Valley.

I, as well as all the residents of O'Brien Creek district are very anxious to have the work continued, but feel that the amount appropriated in the last year is entirely too small to allow the work to be done in a thorough manner.

The work done in this district has decreased the ticks about twenty-five per cent. The residents do not have the fear of infection as in the past and are very anxious to have the work continued.

As yet the work done has not affected land values in this district to any extent. It certainly will if the work done in the future is as effectual as work done in the past.

Yours very sincerely,

(Signed)

W. P. MACLAY.

(NOTE: The O'Brien Creek area in Missoula County has not yet been organized into a control district and, though work has been conducted there during the past two seasons, funds have not permitted the thorough type of work which has been carried on in Ravalli County.)

SPOTTED FEVER IN MONTANA OUTSIDE OF RAVALLI AND MISSOULA COUNTIES

The spotted fever situation in eastern Montana is shown at a glance by the following table. The figures for 1915 and 1916 are also shown for comparison.

Human Cases of Rocky Mountain Spotted Fever in Montana in the Years 1915 to 1918

Counties		1915	1916	1917	1918
Eastern Montana:					
Custer	-----	8	1	---	---
Dawson	-----	6	4	2	---
Rosebud	-----	5	1	---	---
Big Horn	-----	1	---	---	---
Fallon	-----	2	---	---	---
Musselshell	-----		2	2	---
Yellowstone	-----		1	3	---
Fergus	-----		1	3	---
Phillips	-----		1	---	---
Stillwater	-----			2	---
Scattering:					
Carbon	-----	3	1	1	2
Gallatin	-----	2	---	---	---
Cascade	-----	*1	---	---	---
Madison	-----	---	---	2	1
		<hr/>	<hr/>	<hr/>	<hr/>
		28	12	15	3

*This case came in from Idaho and did not originate in Cascade County.

Previous to 1915 spotted fever in eastern Montana was practically unknown. In that year there suddenly appeared a large number of cases for which no adequate explanation is known. Fortunately the strain of the disease there is much less severe than in the western part of the state, the percentage of fatalities running low.

It is highly desirable that further studies be conducted in the eastern part of the state in order that effective advice may be possible. It is our purpose, without neglect of the control work in the Bitter Root valley, to keep in touch with conditions in eastern Montana and, if the opportunity comes, to conduct researches, especially into the habits of the tick under the conditions found there and concerning the relation of the small mammals to the disease.

PATHOLOGICAL WORK BY DR. WOLBACH

Dr. S. B. Wolbach, of Harvard University Medical School, who conducted researches in the organism of spotted fever in 1916 and whose results were published in our last biennial report, has continued his studies during the past two years. His former publication dealt with the pathology and parasite of the disease in guinea pigs and monkeys and also with the occurrence of the parasite in ticks. His more recent studies are concerned with the disease in the human body and are of much value. Dr. Wolbach has made very notable contributions to our knowledge of the obscure organism of spotted fever. The sum of \$525.00 was furnished from the State Board of Entomology fund for the support of Dr. Wolbach's studies, which is very much less than what was expended by him in these studies. In the prosecution of this work he came to Montana and spent some weeks in study at Missoula. His report appears on later pages.

FURTHER LEGISLATION NEEDED

Our experience during the past six years have brought out rather plainly certain insufficiencies in the law and it is very desirable that at the coming session the needs be supplied.

The grazing of domestic animals on unfenced areas has been found to be a condition of much importance in increasing the tick population. Grazing on a commercial scale is being carried on in some cases and in others a few animals are allowed to run at large with little or no attention being paid to keeping them free of ticks. Dipping of such animals is hardly practical as they cannot be gathered up for the purpose with sufficient frequency. The only way to prevent this source of ticks is to keep the animals off the area during the tick season. Commercial grazing along the county roads and in unfenced fields should be prohibited in localities where ticks are present.

ESTIMATED EXPENSE PER YEAR DURING 1919 AND 1920

We have no information on just how much the two federal agencies were expending on the tick problem in addition to what the state was putting in but it is quite certain that they were expending a considerably larger sum than we are asking the legislature for.

Our needs for the coming two years are as follows:

Salary of Assistant Entomologist	\$2100.00
Labor and Assistance during Active Control Season	3660.00
Expense of Field Station in Bitter Root Valley.....	590.00
Traveling Expenses	950.00
Repairing and Filling Vats	300.00
Investigations in Eastern Montana	225.00
Miscellaneous	675.00
	<hr/>
	\$ 8500.00

THE TICK CONTROL DISTRICTS

The boundaries of the tick control districts as originally defined have been published in previous reports of this Board. By action of the Board on April 7, 1917, the boundaries along the eastern side of the district was moved westward in order to exclude from the districts territory which it was considered unnecessary to longer include, because practically no ticks are present.

Therefore, the boundaries as now in force (December, 1918) are as follows:

Boundaries of Control Districts

The west boundary of each of the Florence, Stevensville, Victor, Hamilton and Gold Creek control districts shall be that portion of the west boundary of the state which is included between the intersections of said boundary with the north and south boundaries of each district.

Florence District

North Boundary:

The Missoula-Ravalli County line from a point on the center of the north boundary of section 3, township 10 north, range 20 west, westward to its intersection with the eastern boundary of the Bitter Root National Forest, then

along the east and west extension thereof westward to the Montana-Idaho state line.

East Boundary:

In township 10 north, range 20 west, the north and south center section lines through sections 3, 10, 15, and 22 to the south side of section 22, thence west one-half mile to section corner of sections 21, 22, 27, and 28, thence south along the section lines between sections 27 and 28, and 33 and 34 to the south boundary of the township.

South Boundary:

The line between townships 9 and 10 north in range 20 west, from its intersection with the line between sections 33 and 34 in township 10 north, range 20 west, westward to its intersection with the east boundary of the Bitter Root National Forest, then westward along the east and west extension of said line to the Montana-Idaho state line.

Stevensville District

North Boundary:

The line between townships 9 and 10 north in range 20 west, from a point at its intersection with the line between sections 4 and 5 of township 9 north, range 20 west, westward to its intersection with the eastern boundary of the Bitter Root National Forest, then westward along the east and west extension thereof to the Montana-Idaho state line.

East Boundary:

From the section corner between sections 32 and 33 in township 10 north and sections 4 and 5 in township 9 north along the section lines between sections 4 and 5 in township 9 north along the section lines between sections 4 and 5, 8 and 9, 16 and 17, 20 and 21, 28 and 29, 32 and 33 in township 9 north, thence west one-fourth mile along the township line between sections 5 and 6, township 8 north, range 20 west, to the main county road, thence along the main county road south to Big Creek.

South Boundary:

Same as north boundary of Victor District.

Victor District

North Boundary:

Big Creek west from the north and south county road in section 18, township 8 north, range 20 west, to its intersection with the east boundary of the Bitter Root National Forest, then northward along said boundary to the point where it first turns east, then west along the line between sections 4 and 9 of township 8 north, range 21 west, and its east and west extension westward to the Montana-Idaho state line.

East Boundary:

From point of intersection of north boundary with the north and south county road in section 18, township 8 north, range 20 west, along said road which turns west along center east and west line of the southwest one-fourth of section 18, township 8 north, range 20 west, to the center point of the southeast quarter of section 13, township 8 north, range 21 west, thence south through and to the southern line of section 24, thence west along the southern line of section 24 to where it joins the north and south road along the north and south center line of section 25 and along this road in section 25 to where it joins the Sweathouse Creek road, thence passing west along the Sweathouse Creek road through sections 25 and 26 to the western line of section 26, then straight south along the line between sections 26 and 27, and 34 and 35 to the south boundary of township 8, thence east along this boundary one section to the north and south road on the line between sections 1 and 2 in township 7 north, range 21 west, then south along this road one section, thence west one quarter section along the line between sections 2 and 11, thence south one quarter section to the center point of the northeast quarter of section 11, thence west to the center point of the northwest quarter of section 11, thence south along the middle north and south line of the north half of section 11 to the southern boundary thereof, thence east along the line between sections 11 and 14, and 12 and 13, adjoining the county road at point common to sections 12 and 13, township 7 north, range 21 west, and sections 7 and 18, township 7 north, range 20 west, thence south along this road to Bourne Lane.

South Boundary:

Bourne Lane and the east and west extension thereof extending west from its junction with the county road at the point common to sections 24 and 25 in township 7 north; range 21 west, and sections 19 and 30 in township 7 north, range 20 west, to the Montana-Idaho state line.

Hamilton District**North Boundary:**

Same as south boundary of Victor District.

East Boundary:

Main county road south to Canyon Creek in the southwest one-fourth of section 26, township 6 north, range 21 west.

South Boundary:

Canyon Creek from the main county road in the southwest one-fourth of section 26, township 6 north, range 21 west, west to its intersection with the east boundary of the Bitter Root National Forest, then south along this line to the line between sections 29 and 32 of township 6 north, range 21 west, then along the east and west extension thereof westward to the Montana-Idaho state line.

Gold Creek District**North Boundary:**

Canyon Creek from where it joins the Bitter Root River west to its intersection with the east boundary of the Bitter Root National Forest, then south along this line to the line between sections 29 and 32 of township 6 north, range 21 west, then along the east and west extension thereof westward to the Montana-Idaho state line.

East Boundary:

Bitter Root River south to Lost Horse Creek.

South Boundary:

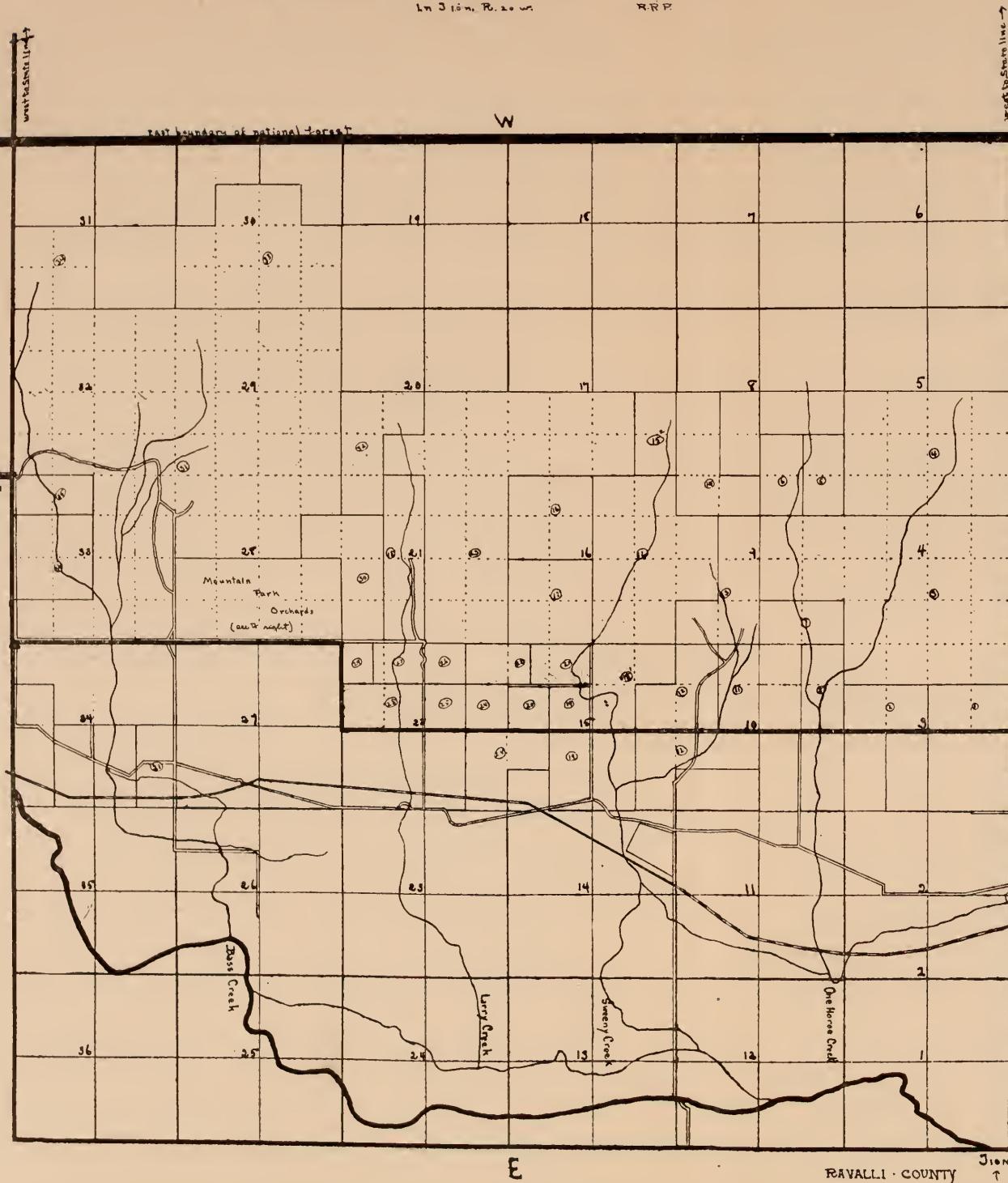
Lost Horse Creek from its junction with the Bitter Root River west to its intersection with the west boundary line of township 5 north, range 21 west, then north or south to the junction of this boundary, with the line between sections 12 and 13 of township 5 north, range 22 west, then westward along the east and west extension of this line to the Montana-Idaho state line.

FLORENCE DISTRICT

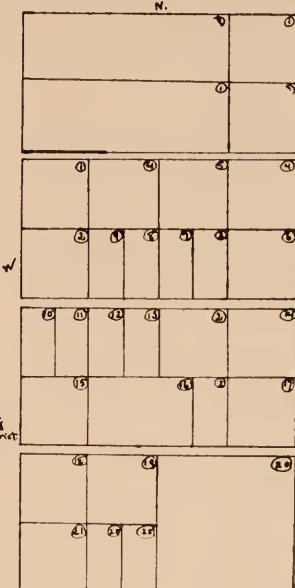
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R.R.P.

STEVENSBURG
BAPTIST

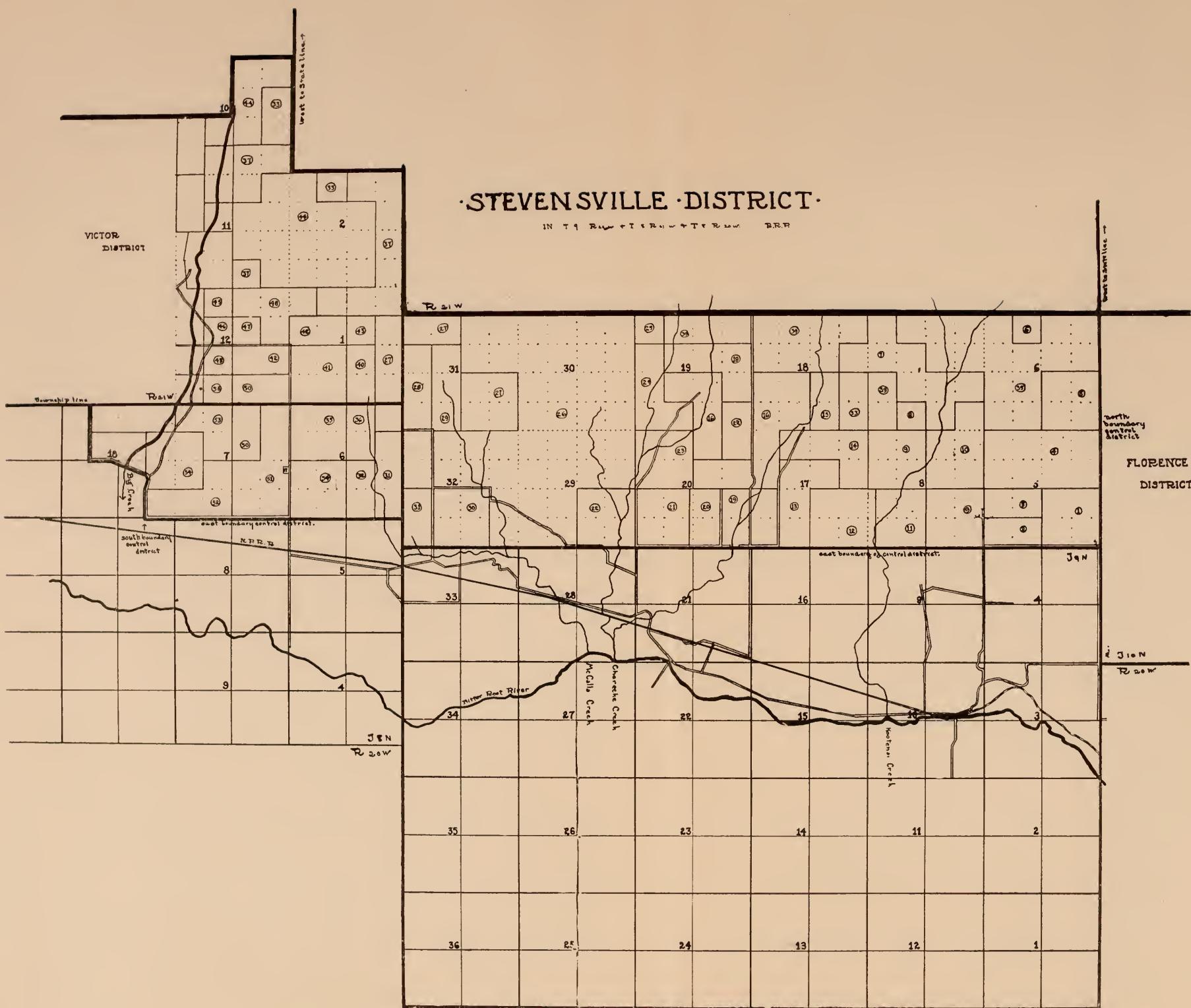


MOUNTAIN-PARK-ORCHARDS



STEVENSVILLE DISTRICT

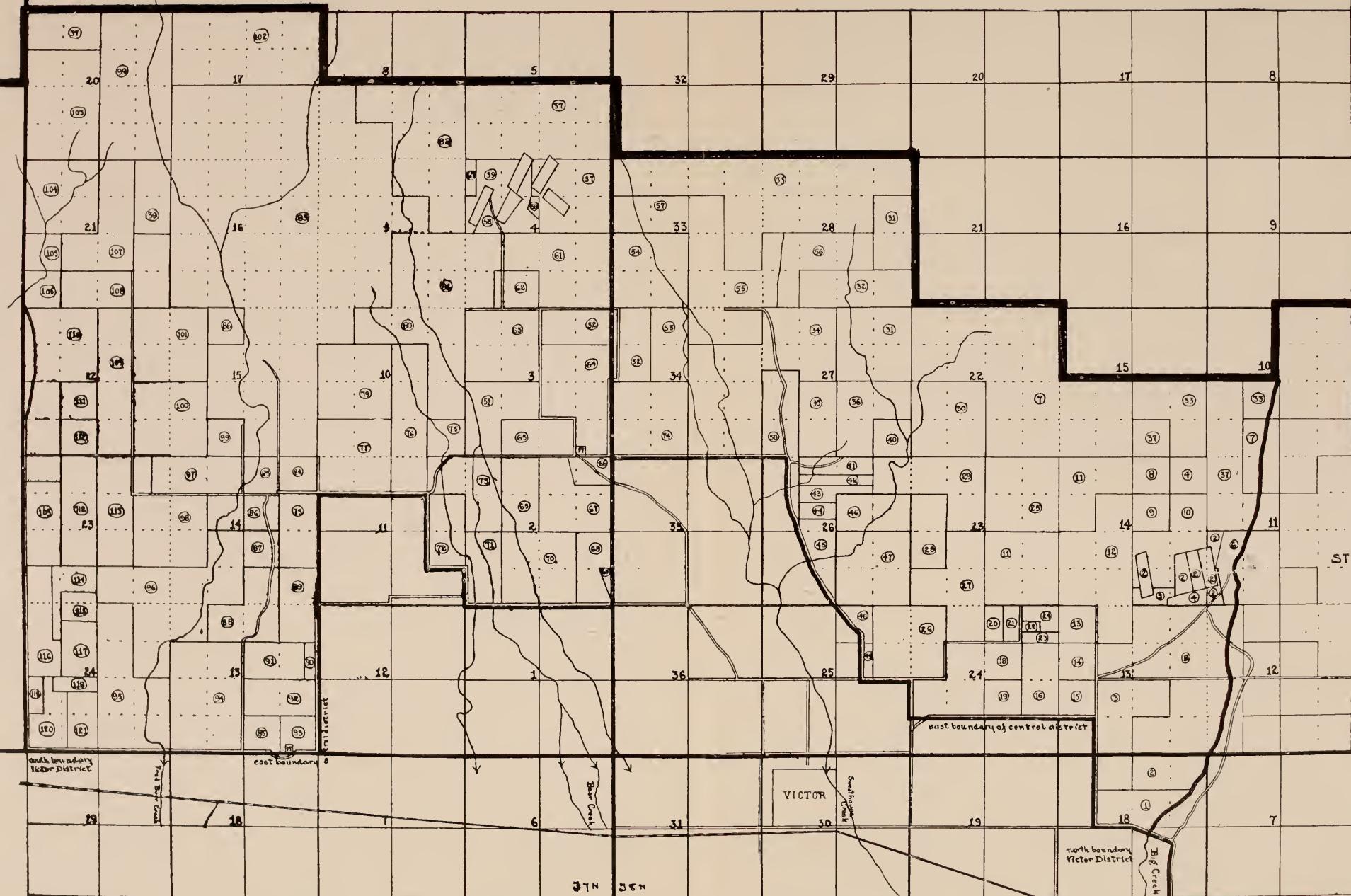
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VICTOR-DISTRICT

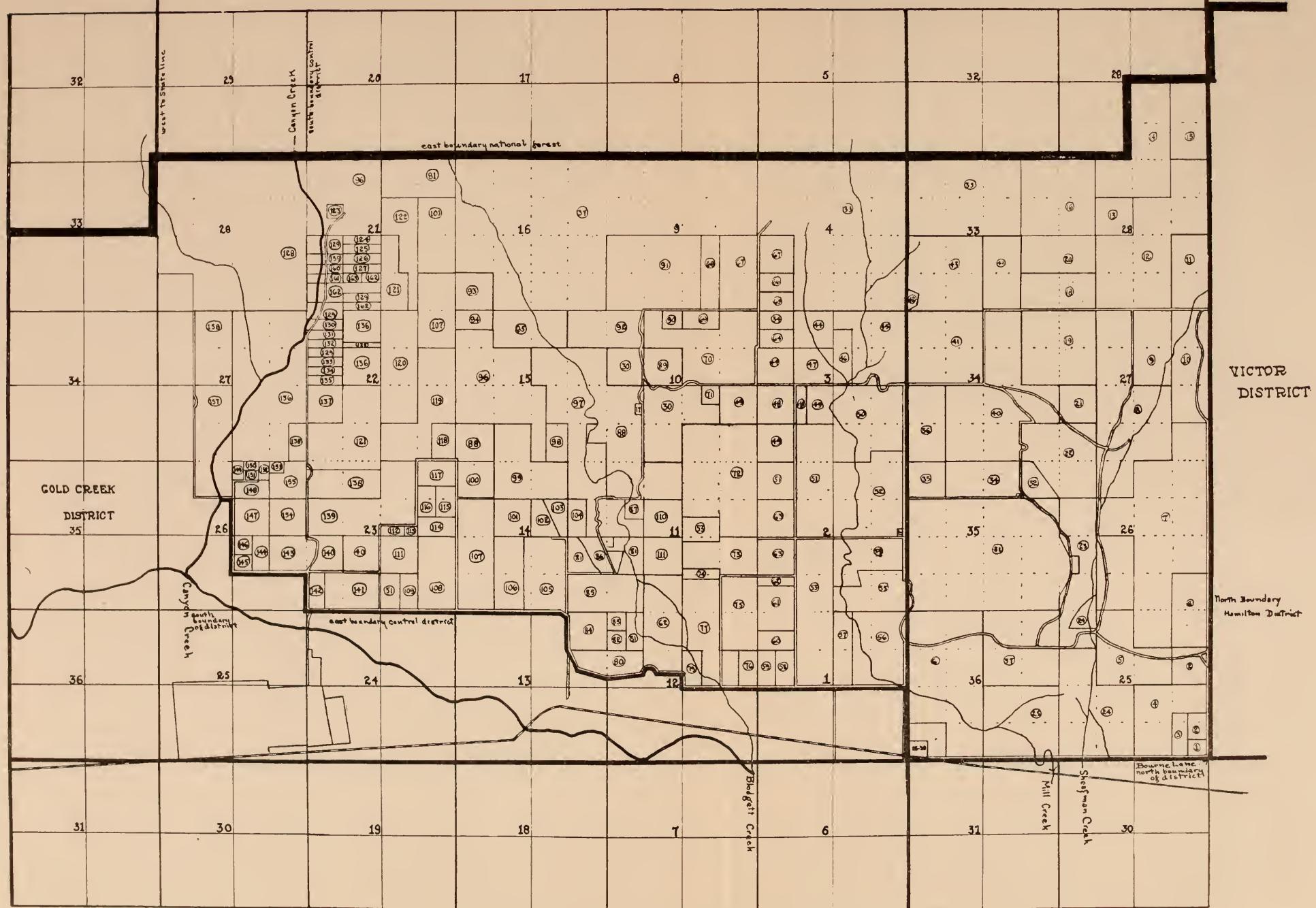
IN TOWNSHIP OF THE DISTRICT

R.M.A.



• HAMILTON • DISTRICT •

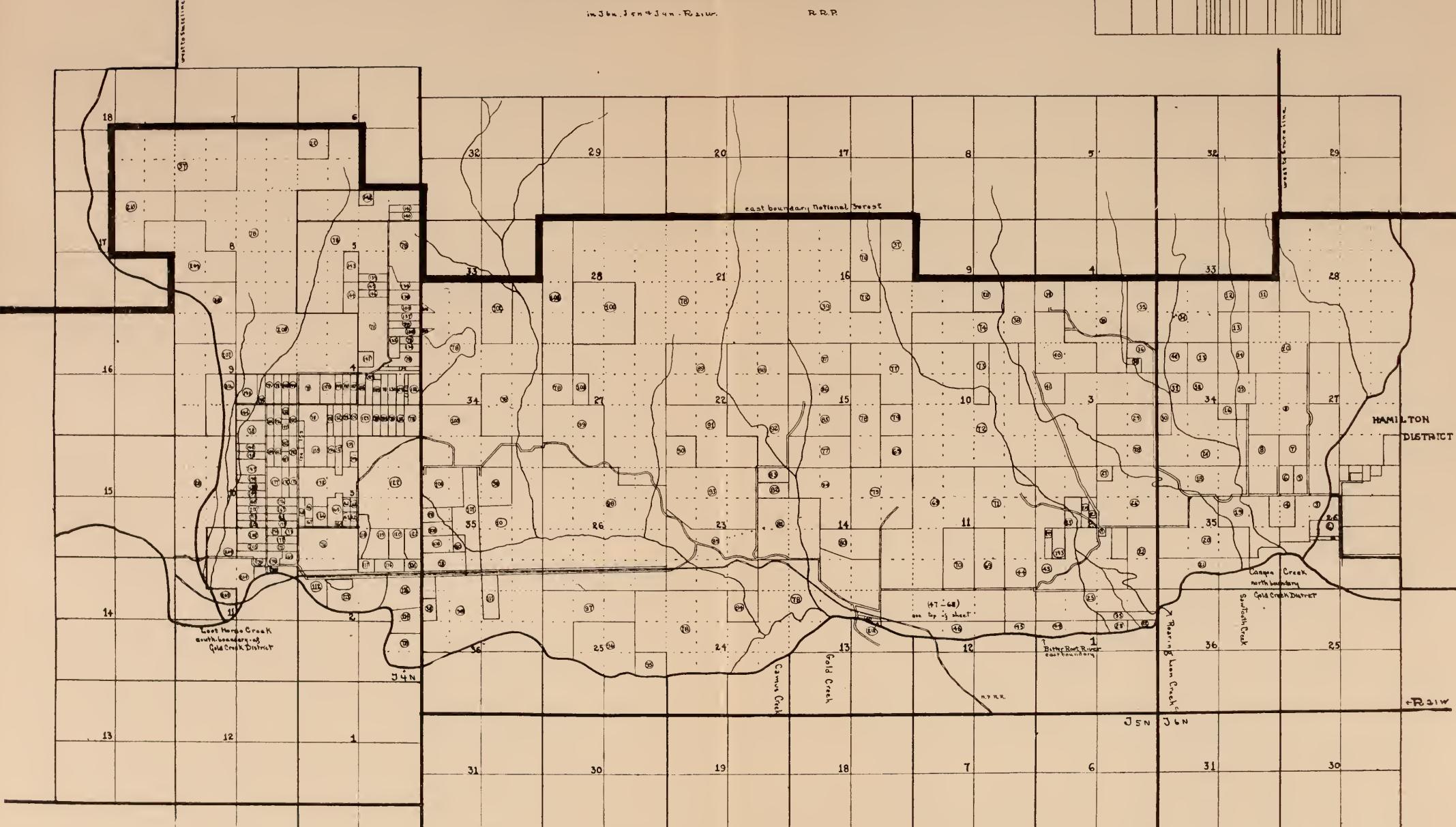
• 10. Tzu & Ton Rumi



GOLD GREEK DISTRICT

in 36, 37, & 34 N. - R. 21 W.

R.R.P.



REPORT OF TICK CONTROL OPERATIONS IN THE
BITTER ROOT VALLEY DURING THE SEASON OF
1918, FACTS IN CONNECTION THEREWITH;
RECOMMENDATIONS FOR THE FURTHER
PROSECUTION OF THE WORK

By R. R. PARKER, Ph. D.
Assistant Entomologist

1. **Organization of Control Work.** The control work carried on in the Bitter Root valley in 1918 under the immediate direction of the writer was largely of an emergency character. ^{To} meet the situation created by the withdrawal of the federal bureaus, with the insufficient funds at hand, called for some changes in the control work, though not so much in the methods of control, as in the agency of application. Each of the federal bureaus had had several assistants employed for the duration of the tick season and extra temporary help when the exigencies of the work so demanded, so that much of the control work was done directly by the representatives of those in charge. On the other hand, the State was represented this season only by the writer and one assistant. The latter, Mr. Henry Cowan of Victor, had previously been with Dr. W. V. King of the U. S. Bureau of Entomology for several years. As a result of the lack of help and for other reasons the Board of Entomology informed the residents and owners in the tick districts that they would be held responsible for bringing their animals to the vats for dipping, and for purchasing and distributing gopher poison on their land.

In order to more intelligently initiate the work a committee of three persons was elected in each district (not in the O'Brien Creek area) by the residents thereof and were of material assistance in planning the work, due to their familiarity with local conditions.

The discussion of the actual control work may be conveniently made under the following heads,—squirrel killing, dipping, grazing, enforcement of quarantine, and educational work. Under each section the work of the past sea-

son will be outlined, its deficiencies pointed out and suggestions made for the future conduct of operations.

The thanks of the writer are due to the County Agent, Mr. L. H. Spring, and other officers of the Ravalli County Farm Bureau, to Mr. W. W. White of the United States Forest Service, to Mr. Taylor of the Bureau of the U. S. Biological Survey, to Mr. J. R. Parker of the Extension Service of the Montana State College, to Professor E. J. Burke of the State Experiment Station, and to many residents of the valley for hearty cooperation and help.

2. **Squirrel Killing.** This work was carried on in cooperation with the Ravalli County Farm Bureau, the U. S. Biological Survey, the Extension Service of the Montana State College, and the United States Forest Service. During the latter part of March Mr. Spring and Mr. Pollinger of the Farm Bureau accompanied the writer to meetings in each of the tick districts in Ravalli County at which the importance of gopher destruction was pointed out, and orders taken for poisoned grain. The poison was later distributed through the Farm Bureau. The poison for the entire county was mixed in Missoula by Mr. Taylor and Mr. J. R. Parker, respectively of the Biological Survey and the State Extension Service. The Forest Service bought poison and distributed it on the edge of the National Forest behind the tick districts. Poisoned grain was furnished to residents at cost of materials, exclusive of labor, namely, 38 cents per quart.

The formula used this spring for gopher poison was the following:

Groats.....	5	bushels
Baking soda.....	8	ounces
Strychnine alkaloid.....	20	ounces
Salt.....	5	pints
Water.....	12	quarts
Gloss starch.....	5	pounds
Saccharine.....	1 1/4	ounces
Syrup.....	1	quart

Wide spread reports of the successful use of the poison were received and very large numbers of ground squirrels were killed. Only in a few instances were reports unsatisfactory and it is doubtful if they were fully justified. Many persons who had purchased an extra supply used it

at all times during the season with gratifying results. Our own results in experimental operations showed the poison to be effective at all times though the squirrels were slower to take it later in the season than when they first appeared in the spring.

So far as actual results accomplished are concerned there is no way of judging as no records of previous infestation were available. Certain deficiencies were apparent in the work, however, mainly due to two circumstances, first, the lack of authority by means of which all parcels of lands could be thoroughly poisoned and, second, the lack of assistance. Because of the first it is safe to say that less than half the land in the districts was treated, largely because the greater portion of the land is owned by non-residents and is mostly unoccupied and much of it unfenced. This is an unfortunate condition because it is such land that constitutes the most dangerous tick territory and where gopher destruction is most urgently needed. Unless a paternal attitude is adopted and this work done free of charge, steps should be taken to adequately provide for the care of such land. Because of the lack of assistance it was impossible to follow up the work of residents and to know which areas had or had not been poisoned and which areas especially needed treatment, or to judge what the general effects of the campaign were. The Biological Survey offered free poison to farmers who would put it out on vacant government land adjoining them, but due to the size of certain such areas it was impossible to secure this aid and the work was not done. Another deficiency was that most persons confined their poisoning efforts to early spring. Though in general it is not feasible to require distribution of poison more than once during the season, yet if the farmers would realize the advantage to themselves of occasionally putting out poison as long as the squirrels are abroad, inestimable good would be accomplished. Steps to improve this condition should be taken next year. County and state land was not poisoned this year, though the county attempted to poison roadsides through the agency of road supervisors. With sufficient funds and assistance and by agreements with the county authorities it should be possible to properly care for this work in the future.

An interesting condition of affairs occurred this season, due to unusual weather conditions. Because of an early spring much green vegetation was in evidence prior to the appearance of gophers during the second week in April. This in no way seemed to affect the efficacy of the poisoned grain, as has been so commonly believed. Later in the season, due to unusual and prolonged dry weather, gophers in large numbers came down from the foothill country into the valley. Land which had been practically cleared of gophers by the early spring poisoning was, in some instances, more severely infested than before. Gardens were freely invaded and considerable damage done. This stimulated many farmers to a late season use of poisoned oats with beneficial results, both to themselves and to the tick work. In a general way it is likely that this migration of gophers to the valley is to be considered more advantageous to the tick work than otherwise, both because it is probable that the number of gophers in the dangerous foothill country was reduced and because the gophers are easier to deal with in the valley than on the waste land above. How extensively the squirrels may have gone back to the hills to hibernate is unknown. It is also a question whether or not so many gophers coming down from the foothill country may not have carried infected ticks into the valley.

There were certain disadvantages in the use of the above poisoned grain formula which it is hoped to remedy the coming season. These were its high cost and the fact that other cheaper formulas were found to do better work later in the season. Whether the latter will be as efficient in the early spring remains to be seen.

The district committees rendered valuable aid in the gopher work by informing the writer of areas unlikely to be treated by the owner, by urging the use of the poisoned grain and frequently by doing work themselves that would otherwise have been neglected. Vacant areas which the owners were unlikely to poison were located in this way and were frequently poisoned by neighboring owners, free poison for the purpose being provided through the kindness of Mr. Taylor of the U. S. Biological Survey.

3. **Dipping.** The dipping program outlined by the Board for the past season specified that the vats should be filled and the solution tested and kept at proper strength by the state and that assistance for dipping should be furnished so far as possible, while upon the residents owning stock for dipping was placed the responsibility of getting their animals to and from the vats. This differed materially from the practice of the federal bureaus in the fact that no aid was furnished stock owners in bringing in or returning their animals. In past years many persons had never pretended to assume this responsibility.

Some difficulty was met with in putting into practical operation the state end of this program because funds only permitted the employment of a single assistant whose duties could not be entirely confined to vat work. With six vats to operate and a ten-day interval dipping schedule to be adhered to in each district the situation was somewhat complicated. In order to meet the situation as fully as possible an arbitrary schedule was announced for each district, with the understanding that when the scheduled days were not suitable for dipping, stock should be brought in on the first favorable day thereafter. This arrangement had obvious disadvantages but was the best that could be devised to meet the conditions. The situation was helped somewhat by the kindness of Mr. W. P. Maclay who offered to take charge of the dipping in the O'Brien Creek area near Missoula and many farmers agreed to dip their own stock in case a conflict of dates should make it impossible to be at certain vats on the scheduled days.

The first of the vats was filled on March 30th, the last on April 18th. The solution used was made up according to the Bureau of Animal Industry boiled dip formula except that the amount of white arsenic used was carefully computed. Vat capacities were available in some instances but had to be figured in others. The results were satisfactory, both as regarded tick killing properties and absence of injury to stock.

The galvanized iron vats at Florence and at O'Brien Creek were found in good shape but the four cement vats in the Stevensville, Victor, Hamilton and Gold Creek districts required more or less repair due to leaks and defective

corrals. Both the vat and the corrals at Gold Creek were in very poor shape due to poor choice of site. Quite extensive repairs will be needed at this vat and at the O'Brien Creek vat another season. In the latter case the injury was due to the breaking of the ditch on the hillside above the vat, the water causing the ground to cave in against it.

Because of weather conditions dipping according to the prepared schedule was not feasible before the first of May, while frequent unfavorable days even after that date seriously interfered with the work. The best results were secured at O'Brien Creek where over 900 head were dipped during the season. In that particular area there is less prejudice against dipping and it is therefore much more successfully carried on than in the Ravalli County districts.

In view of the experience of the past season in attempting to enforce a dipping program several facts pointed to the advisability of discontinuing **compulsory** dipping in the future. Recommendations to this effect and reasons therefor were submitted to the Board during the summer and these met with their approval. It has been necessary, therefore, to work out compensating measures which will be efficient and also be adaptable to local conditions. These measures will be effective in the season of 1919.

In suggesting a modification of the practice of dipping the underlying reason is not concerned with the reliability of dipping as a means of ridding a given area of ticks but with the compatibility of the practice with certain existing conditions. One of the most important of such conditions is that relating to animals which range on the vacant land along the foot of the mountains between the farms and the forest reserve boundary. In a general way this is the most dangerous tick territory, yet no adequate provisions are possible to insure the dipping of animals ranging there. This, together with the fact that all such land is heavily gopher infested and particularly difficult to free of them, (a fact which makes a high efficiency in dipping all the more necessary), due to the character of the country and because the owners are non-residents, points to the inadvisability of relying upon dipping as a means of eradicating ticks on such areas.

Other factors which mitigate the efficiency of dipping are: (1) the difficulty of enforcing a dipping program, due to lack of interest and occasionally to prejudice on the part of certain stock owners, (2) it is not feasible to dip animals except on warm sunny days, and this precludes the possibility of starting systematic dipping much before May first, and even after that date many unsuitable days occur, (3) the labor situation on farms at the present time is such that the sacrifice of time called for in a ten-day dipping schedule is much greater than in years past. There is also another consideration, namely, that the control work in many localities has reached a stage at which it is doubtful if there is as great benefit to be derived from compulsory dipping operations in the future as in the past, while there is reason to believe that quicker results can now be obtained by other methods, namely, more thorough gopher destruction and the restriction of grazing on unfenced land.

4. Grazing. The grazing work as outlined for this year was an effort to get as many range animals as possible out of the tick districts during the season of adult tick activity, from early spring to about the first of July. To this end the Forest Service cooperated by offering the free use of the range on Eight Mile Creek and elsewhere, providing all the range animals in a given district were removed.

Under the above arrangement the range on Eight Mile has been used for stock from the Florence district for several years. This season range animals from the Stevensville district as well were placed there. In the other three districts to the south it was impossible to persuade a sufficient number to take their stock to reserve ranges, though the prevailing sentiment favored it. In other words, those willing to cooperate were prevented by those who were not. Some would not consent, but gave no reasons; others were afraid of cattle thieves, others of poisonous plants, and so on. The owners of the stock grazed on Eight Mile Creek this season agreed among themselves to dispense with the services of a herder, believing that a certain loss was always to be expected and that under the conditions on the range in question the services of a herder would not prevent this. The Bureau of Entomology had paid half the expense of herding in previous years.

From the standpoint of the tick control work the grazing problems resolves itself into five parts; (1) grazing of milk stock and work animals on fenced areas, (2) grazing of other than milk stock and work animals on fenced areas, (3) grazing of animals on unfenced land, (4) roadside grazing and (5) grazing in the forest reserve.

Grazing of milk cows and work horses within fenced areas is not objectionable if the owner agrees to hand pick the ticks at frequent intervals and the land is thoroughly poisoned for gophers once each season. In the grazing of other than milk stock and work horses in fenced areas there is greater danger of female ticks engorging as such animals are not frequently handled and except in occasional instances cannot be hand picked. To take the place of dipping it is suggested that owners of such pasture land be required to poison for gophers twice during each season and for their own best interest should be urged to use poisoned grain at any and all times when they find gophers on their land.

The grazing of horses, cattle, and sheep on the unfenced waste land lying between the farms and the mountains and largely owned by non-residents and in part by the government in a most dangerous practice and its influence on tick abundance is hard to combat. This land is heavily infested with gophers which, under existing laws, can only be poisoned at the public expense. Cattle grazing on this land are often difficult to find and get to the vats, particularly, it so happens, in those districts when the tick situation is least favorable. This is even more aggravated in the case of horses and mules which wander farther in the mountains than cattle and are much more difficult to find and to get to the vats. Regarding sheep it need only be said that it would be a very dangerous proceeding to permit these animals in the foothill country as there is every reason to believe that they would ultimately greatly increase the number of ticks, and it is not feasible to dip them for several reasons. The situation, then, is essentially as follows;—this territory, the most dangerous at the present time, is also the most difficult to handle because of unrestricted grazing, the result of which is maintaining a dangerous infestation of ticks cannot be adequately controlled by dipping; while the complimentary method of tick

control through the destruction of gophers cannot successfully be used under existing conditions (except at prohibitory expense to the state) because the land is largely owned by non-residents. The means recommended to meet this situation involve the restriction of grazing on land of this character until such time as the dangerous conditions now existing are cleared up and the poisoning of such land for gophers twice each season at the owner's expense. Both suggestions will, I am sure, meet with a favorable response on the part of the great majority of the residents of the districts. The chief objection will come from some few owners who are not inclined to remove their stock from the districts. In some instances pastures in or close to the districts will be available. The proposition to require owners to stand the expense of poisoning for gophers is fair to all concerned. It is fair to the farmers in the valley below, as this territory has always been a breeding ground from which gophers migrate to the agricultural lands, mitigating the efforts of the occupants to control them; furthermore, it is the residents of the agricultural sections of the districts who have thus far borne the brunt of the control work and it is only fair that the non-resident owners whose land is the less safe should share their part of the burden of the work. It is fair ~~to~~ the non-resident owners whose land is the less safe should share their part of the burden of the work. It is fair to the state as offering a means by which the land concerned can be more quickly and effectively cleaned up, thus decreasing the ultimate expense of the work.

Roadside grazing has been quite generally practiced within the limits of the tick districts, adding to the difficulty of the control work. It should be prohibited or controlled.

The placing of all animals possible on the forest ranges during the season of adult tick activity has been previously mentioned as most desirable. If the suggested prohibition of grazing on unfenced land is made effective it will doubtless result in an increased use of these ranges. To overcome some of the objections of those who are opposed to so disposing of their animals during the tick season it has been suggested that the owners of range animals form a "Stock Grazing Association" and place the handling of their

animals in charge of a committee, the functions of which would be to locate range, supply herders, provide for salting, etc. In this ~~way~~^{owners} would be assured that their stock would have good care, and the responsibility would be taken from their shoulders. This arrangement would, doubtless, appeal also to some who have pasture for their animals and to others outside the districts. In fact, a county organization would be the best solution and might well be formed under the leadership of the Ravalli County Farm Bureau. It should be pointed out that by using the forest ranges during the spring months the range land in the tick districts will be all the better later in the season when most needed.

5. Quarantine Enforcement. The enforcing of the quarantine regulations was carried out to the best of the writer's ability. Doubtless violations occurred as there was no means of knowing of such violations except by chance or when persons were willing to report them. One condition arose this season that will be prevented by prohibiting grazing on unfenced land. In the instance referred to several animals were purchased from each of a number of persons residing in the districts. These were combined in one herd and turned loose on the unfenced waste land in the Victor district. This was not fair to the residents of that district.

As an aid to enforcing quarantine regulations and in fairness to people both in and out of the districts it is suggested that quarantine signs be posted on all roads leading into the districts at the boundary thereof.

6. Burning. Though burning is not recognized as part of the tick control work, some mention of it is necessary because of the confidence which many farmers repose in this as a method of control. There is no question but that burning results in the destruction of a greater or less percentage of the infesting ticks and it is equally certain that it does not destroy them all. Direct evidence to this effect was secured by the accidental burning over of an area on which marked ticks had been placed for experimental purposes. Some dead marked ticks were found, but also some marked ones that had survived. Burning cannot be considered as anything more than an accessory control measure, its indirect value through the cleaning and clearing of land being as

great or greater than its value by the actual destruction of ticks. Furthermore, it should be borne in mind that thorough burning, such as will be most effective, is rarely accomplished and that rocky areas where ticks are frequently most abundant cannot be burned at all. Wherever attempted it should be carried out in the most thorough manner possible and repeated each season, or as frequently as conditions will permit. Otherwise it may be productive of more harm than good.

7. Educational Work. This was a definite part of the control program and one to which it was impossible to devote the time and attention deserved. In the early spring meetings were held in all the tick districts and the character of the work and the reasons therefor explained in as much detail as possible. Such meetings, however, reached only a small part of the people and those who least needed the knowledge. In company with the County Agent, Mr. L. H. Spring, talks were given in other parts of the valley. Articles of an educational character were submitted, from time to time, to the county papers and the Ravalli County Farm Bureau News. Other material was published through the medium of correspondents. It is expected to continue the work of this character as the lack of knowledge even among residents of the districts is often surprising. It is believed that a brief bulletin discussing the why and wherefore of tick control methods and the reasons for any changes that may be put into effect the coming season should be published and sent to all residents of the districts as early in the spring as possible.

Some Factors Affecting the Efficiency of the Control Work

8. Meteorological Conditions. Previous mention has been made of the fact that the unfavorable weather conditions have been a considerable factor in retarding successful dipping operations. There has seemed to be no other means to remedy this trouble than the adjustment of the dipping program before mentioned.

9. Attitude of Residents. Such opposition as exists among the people to the control work is due to several reasons,—(1) disbelief in tick transmission of the Rocky Mountain spotted fever, (2) sacrifice of time necessary to

carry out their part of the control work, and (3) the idea prevalent among many that the use of gopher poison is dangerous to their domestic animals. These difficulties can be overcome to some extent by educational work, by compulsory gopher poisoning, and by some of the suggested changes in the control program.

10. Ownership of the Land. The large amount of land in the Ravalli County control districts owned by non-residents is a serious obstacle in the way of efficient work against the tick. As shown in the accompanying tables the total acreage involved in the parts of the districts that are outside the Bitter Root National Forest is about 76,000. Of this land nearly 54,000 acres is owned by persons not residing on the land, and more than 38,000 acres, nearly one-half the total area, by persons residing outside the county. Putting it in another way, of more than 600 owners of land in these districts only 181 reside on their land while 412 reside outside the districts and the majority of these outside the state. In the Gold Creek district only 25 out of 214 owners are on their land and 184 are known to reside elsewhere. Of a total acreage of nearly 12,400 in the Florence district, approximately 11,000 acres belongs to non-residents, and of more than 20,000 acres in the Gold Creek district over 17,000 belong to non-residents. These figures speak for themselves.

Table Showing the Approximate Amount of Land in the Tick Control Districts Owned by Residents and Non-Residents and Other Data

Districts	Total Acreage	Owner Lives on Land	Owner Does Not Live on Land	Information Lacking	Land Vacant	Land Rented
Florence	12,386.36	1,779.00	11,007.36		6,904.00	1,865.00
Stevensville	10,988.00	4,001.00	6,558.00	429.00	4,242.00	2,354.00
Victor	17,446.09	5,894.49	11,376.38	175.22	7,445.18	3,911.12
Hamilton	14,471.10	6,141.10	7,706.80	523.20	3,449.10	2,047.00
Gold Creek	20,764.68	3,398.60	17,075.78	290.30	6,097.82	2,022.50
	76,456.23	21,214.19	53,724.32	1,517.72	28,138.10	12,199.62

Acreage owned by non-residents living outside the county, 38,146.64.

**Table Showing the Approximate Number of Owners Residing
on Their Land in the Control Districts, the Number
Residing Out of the Control Districts and Other
Data Related Thereto**

Districts	Total Owners	Owners on Land	Owners Not on Land	Parcels of Land Rented	Parcels of Land Vacant	Information Lacking
Florence	58	15	43	32	9	0
Stevensville	53	17	35	15	22	1
Victor	119	53	66	35	35	0
Hamilton	160	71	84	15	28	5
Gold Creek	214	25	184	25	105	5
	604	181	412	122	199	11

The importance of this high proportion of non-resident owned land is that most of it is unfenced, unoccupied, non-agricultural, and lies along the foothills and the mountain slopes between the occupied agricultural land in the valley and the eastern boundary of the Bitter Root National Forest. Much of it is cut over timber land. It is also by far the most dangerous tick territory at the present time because of the ideal tick conditions furnished by the unrestricted grazing of range animals and the immense number of ground squirrels that infest it. In attempting to carry out the control work this season the writer found himself without means of caring for his land. Dipping could not solve the problem for reasons previously stated, while there was positively no way of attacking the gophers. Some owners agreed to poison but others it was impossible to reach. At present the persons residing on the agricultural areas of the districts, which are the least dangerous, are bearing the burden of the control work, while those owning the most dangerous land are doing nothing except that, by their inaction, they make the work of the residents and of the State Board more difficult, more long-drawn out and more expensive.

The following suggestions for remedying this state of affairs have been stated before but are offered again for

sake of clearness,—(1) prohibit all grazing on land of this character, (2) provide that it may be poisoned for gophers twice during each season by representatives of the state and the cost of such work to be borne entirely by the owner of the land.

11. Follow-up Measures to Determine Progress of Control Work. In the program under which circumstances dictated that the control work should be carried on during the past season there was evident a very fundamental need. This was the means of determining just what progress was being made, in what areas the work was effective or otherwise and the reasons therefor. There was no way of meeting this need which necessarily called for adequate funds and necessary assistance. The plan suggested to meet this deficiency in the work is to determine the infestation of adult ticks on each separate unit of territory by "dragging" during the season of adult tick abundance. Permanent records of this character would show the results from year to year of control operations and would show when it would be wise to declare territory free from ticks and release it from the control districts. Examination of gophers from each such area for larval and nymphal ticks each season would greatly add to the value of the records. This feature cannot be definitely incorporated into the plan, however, for the reason that, if the gopher work is as successful on a large scale as on the trial work of the past season, gophers would be too scarce to waste time attempting to secure them for examination.

The examination of domestic animals for ticks whenever pastured in an enclosed area will also furnish a valuable index from year to year of what is being accomplished.

Without such information as can be obtained by the means just enumerated the intelligent direction of the work by the persons in charge will be greatly impaired and any positive knowledge of the results of the work will be impossible.

Results of the Tick Control Work

12. The Abundance of Ticks. In general it may be said that the abundance of ticks has been very materially reduced and some parts of the districts are essentially tick free, thanks to the efforts of those who have previously

been in charge of the work. The condition varies somewhat, depending on the locality. The best condition exists in the valley from the Missoula county line south about to Bear Creek. From there south conditions are less favorable, especially in the Gold Creek district. On the foothill land mentioned in section 8 the reduction of ticks is not so striking, though much good has been accomplished, especially to the north. The most thorough gopher work has probably been done in the vicinity of Victor, where the work was begun by Dr. McClintic in 1911, and the results there are satisfying evidence of the value of systematic and thorough gopher destruction. Considering the many difficulties that have stood in the way of intensive control work the results are remarkably good.

13. Mammals and Their Relation to the Fever Tick. With the possible exception of rabbits, there is, at the present time, no occasion to devote special time to other mammalian hosts of the tick than the Columbian ground squirrel. It should be noted, however, that the advisability of such a course of action may become evident in the future in the Bitter Root valley or elsewhere, especially as conditions in the valley are cleaned up and the tick work resolves itself into a question of possible future conditions, rather than with the present. It may be well, for example, to eradicate mountain goats from the vicinity of the tick districts.

14. Investigation. The practical features of the control work left scant time for investigation. The only work of the kind systematically attempted was for the purpose of finding a gopher poison which would be cheaper than the groats formula and equally efficient. The use of groats would make poisoning work somewhat expensive when continued throughout the season as hoped for next year. The formula used by the Biological Survey was tried, 8 quarts of crushed oats being substituted therein for 12 quarts of whole oats (crushed oats, 8 quarts; sodium bicarbonate, 1 ounce; saccharine, 1 teaspoonful; strychnine, 1 ounce; starch, 1-2 pound; water, 3-4 quarts). Excellent results were obtained. Both this formula and the whole oat formula of the Biological Survey were found to be superior to the groats. The crushed oats were given a

thorough tryout from May to the end of the season and found efficient in all sorts of crops and in all locations. Aside from efficiency it has advantages over both the groats and the whole oats for the work in the tick districts.

SECOND REPORT ON INVESTIGATIONS OF THE ROCKY MOUNTAIN SPOTTED FEVER TICK IN EASTERN MONTANA

By R. R. PARKER

The investigations ~~of~~ the habits and host relationships of the Rocky Mountain spotted fever tick, which were commenced in 1916 with headquarters at Powderville (See Second Biennial Report, page 45-56) were continued during the season of 1917 at Musselshell in Musselshell county. The change in location was dictated by conditions of accessibility, occurrences of the fever, abundance of ticks, and faunal and floral conditions. Trips to other localities increased the comprehensiveness of the work.

The writer had for his assistant, Mr. R. W. Wells, who had been previously associated with him in the work in the eastern part of the state and who, because of his industry and ability, very materially aided in securing the results herein recorded.

Character of the Country.

The character of the country was found to have a fundamental influence on the abundance of the wood tick. Whereas the vicinity of Powderville was essentially a prairie country, characterized by sagebrush, prairie grasses, and very limited tree growth, that area south of the Musselshell River to which the work in 1917 was largely confined was essentially hilly, consisting of hilly, pine-wooded areas separated by narrow valleys from which much narrower, many branched coulees extended far back from into the hills. Most often the valleys and hills were joined on one side by very steep, rocky slopes, (such slopes were commonly wooded), frequently surmounted by sandstone rimrocks while on the other side, the slopes from the valleys to the plateau-like summits were usually less abrupt and not so rocky. In the coulees, which were at right angles to the valleys, both sides frequently conformed to

the type first mentioned. At the foot of the cliffs, or so-called rimrocks, and on the slope beneath were accumulations of rocks that served as admirable habitations for the small host animals of the larval and nymphal ticks.

Wild Animals as Hosts of Immature Ticks

The accompanying table (1) presents in tabular form the results of the examination of wild mammals for larval and nymphal ticks. A total of 557 animals were examined as follows: prairie dogs, 65; deer mice, 343; field mice, 26; house mice, 18; chipmunks, 94; jack rabbits, 7; cottontail rabbits, 9; pack rats, 3; porcupines, 5; and pocket gophers, 2. No immature ticks were found on house mice, muskrats, porcupines, and pocket gophers.

Prairie Dogs. Of 65 prairie dogs examined only 2 (3.18 per cent) were found infested, and each with a single nymph. This result fully agreed with previous data, indicating that these animals are of little practical importance as tick hosts.

Deer Mice. In the discussions of the results with deer mice, field mice, pack rats and chipmunks it should be understood that there is a potent source of error involved. This is particularly true of mice. Deer mice were, for the most part, caught between ten and twelve at night and lay on the ground until collected in the morning. Though this collection was made as early as possible, it was usually

Table 1. Tabulation of Results of Examinations of Wild Mammals for Larvae and Nymphs

HOST	Number Examined	Number Larvae	Average Larvae	Number Nymphs	Average Nymphs	Total Infestation	Per Cent Infestation	Average of Nymphs and Larvae
Prairie Dogs	65	.....	.....	2	.03	2	3.18	.03
Deer Mice	343	336	.98	93	.27	84	24.52	1.25
Field Mice	26	112	4.35	21	.81	19	73.08	5.15
House Mice	18	0	.....	0	.....	0	.....	.....
Chipmunks	94	46	.49	140	1.49	51	54.25	1.98
Jack Rabbits	7	63	9.00	0	.....	1	14.28	9.00
Cottontail Rabbits	9	18	2.00	11	1.22	6	66.66	3.22
Muskrats	5	0	.....	0	.....	0	.....	.....
Pack Rats	3	34	11.33	3	1.00	1	33.33	.....
Porcupines	5	0	.....	0	.....	0	.....	.....
Pocket Gophers	2	0	.....	0	.....	0	.....	.....

7 to 10 hours after death. Therefore, it was suspected that the ticks might begin to leave the host some hours before they could be collected and examined, and that our results were not indicating the true importance of these animals as tick hosts. By working at night and by careful examination of the ground around traps this suspicion was confirmed. For instance, to cite a few examples from the deer mice records;—April 26, 8 nymphs from ground, none on host; May 12, 2 nymphs picked up, none on host; August 5, 65 seeds and nymphs around host, and 60 more on host. The most careful searching of the ground would often fail to reveal the ticks for several minutes. In the last case cited the writer spent 30 minutes of careful searching for the 65 ticks found. In general ticks were within 4 inches of the host, but sometimes 6 or 8 inches distant, and were even found under stones. Among litter it was practically impossible to find them. It is apparent then that the figures given for the average infestation of the animals above mentioned are below the actual truth.

So far as observations made to the present time may be taken as an indication, deer mice are only second in importance to jack rabbits in their relation to the tick, the jack rabbit assuming first rank because it is a host of all three stages of the tick and because it is susceptible to the disease. The importance of this mouse is due to the following facts;—first, it far exceeds in abundance all other wild mammal hosts of immature ticks combined, second, its wide distribution and adaptability to all sorts of conditions, and third, it is an efficient host of larvae and nymphs. The degree to which these mice are infested depends largely on the combination of conditions present in any given locality. Every variation was found from the locality where an infested mouse was a rarity to that in which all were infested. Some idea of this variation may be gained from the following list of captures on different homesteads each presenting different conditions of topography and of adult host relationships. In one particularly heavily infested locality an average of 19.88 ticks per mouse was secured for one day's catch. In another instance 125 were taken from a single mouse, 39 of them fully engorged.

Homestead	Number Mice Captured	Average Ticks Per Mouse
1	24	1.29
2	24	4.83
3	32	.78
4	30	1.13
5	25	7.84
6	54	0.00
7	47	.02

The average infestation for 307 mice taken at Powderville was .19 (in a poor tick season), that for 343 mice at Musselshell 1.25. In prairie country these mice were found in every conceivable situation, while under the hill conditions near Musselshell they were abundant only on the rocky slopes along the edges of the valleys.

Field Mice. The possible importance of field mice was suggested by the work at Powderville where the same average infestation was found as for deer mice. Under Musselshell conditions more definite data were secured, and for 26 mice examined the average infestation with larvae and nymphs was 5.15, while the average for 9 taken from a badly infested coulee on August 5th was 10.73. This high seasonal average does not mean that they are in any way comparable to deer mice as tick hosts. They distinctly are not. It is only when favorable habitat conditions occur, combined with the necessary hosts for adult ticks (and this is not frequent), that they are a factor to be reckoned with. The problem presented by these mice, then, is one which affects individual homesteads and ranches and not a generalized control system.

Chipmunks. As was the case with deer mice and field mice the Powderville studies suggested the importance of chipmunks; the per cent found infested was 41.18. Under strictly prairie conditions, however, which did not constitute an ideal habitat for these animals they were much less common than in the hill country at Musselshell and did not seem to be an essential factor in the abundance of ticks. Under special prairie conditions such as the small wooded areas (only a few acres in extent) included in u-shaped bends of the rivers where the underbrush was heavy they were found very numerous, however. Such places favored their abundance, whereas strictly prairie conditions did not,

so that wherever they occurred chipmunks were very important tick hosts. The controlling factor was the change from prairie vegetation to tree growth and underbrush.

At Musselshell 94 chipmunks were examined and 51 (54.25 per cent) found infested. The number of larval ticks found was 46 and of nymphs 140. In one instance 31 nymphs were taken from a single chipmunk. Like deer mice the chipmunks were found most abundant in the vicinity of slopes leading the rimrocks, though they were by no means so restricted to such places as were the mice.

Chipmunks and deer mice were the two most important hosts of immature ticks in the hill area studied for the season of 1917. That they are always important is seemingly an assured fact but that they would be always the "most important" as in the particular season in question is another matter. Rabbits, both jacks and cottontails, had been very numerous in that locality till about a year before our studies commenced. Pack rats, which as well as the rabbit seemed to have been almost exterminated, were normally quite abundant and are also very efficient hosts of larval and nymphal ticks. With these animals at a point of maximum abundance along with deer mice and chipmunks, the latter would lose to some extent the important position assured them in 1917.

Jack Rabbits. As just stated, jack rabbits were very scarce in the locality where our intensive work was carried on in Musselshell county and only one was secured under hill conditions. This carried two male ticks. Six others shot on the prairie in the northern part of the county carried, respectively, 4, 4, 2, 0, 0, adult ticks and 64 larval ticks. The males predominated as found at Powderville. Other facts relating to the importance of jack rabbits were given in the Second Biennial Report of this Board.

The jack rabbit (perhaps other rabbits should be included) merits distinction as being, potentially at least, the most important wild mammal of eastern Montana in its relation to the spotted fever tick. This is due to the following reasons: first, it is the only animal known to be a host of all three stages of the tick; second, it is likely that rabbits alone can maintain an infestation of ticks without the presence of other hosts of the adult stage; third, it has a

wide traveling radius; fourth, it is susceptible to Rocky Mountain spotted fever; and fifth, there is reason to believe that rabbits may play an important part in the spread of the disease, both extensively and intensively.

Interesting observations of the past two seasons have pointed to a frequent coincidence of the abundance of ticks and the abundance of rabbits preceding or coincident with occurrences of the fever. It is well known that in many regions rabbits will suddenly increase after several years of ~~regular~~^{RELATIVE} scarcity and then after a few years of abundance as suddenly die off, due to causes not well understood. The interval between such epidemics is variable, but seven years has frequently been recorded. At Powderville rabbits reached their height of abundance in 1914 and died off in great numbers during the winter of 1914 to 1915 and for some time thereafter. The latter year was that of unusual tick abundance in that locality and several cases of fever occurred. Similarly the unusual prevalence of the disease in Modoc and Lassen counties of northern California in 1915 and 1916 was preceded by great rabbit abundance in 1914 and 1915. Other instances might be cited, but it is sufficient to say regarding eastern Montana conditions that in a general way the occurrence of the disease in the years 1915, 1916 and 1917 moved steadily westward while the height of rabbit abundance preceded or seemed to be coincident with it. The westward movement of the height of rabbit abundance reached the limit of prairie country in 1917. In this connection it is desired to point out that a periodic increase in the abundance of rabbits means a periodic increase in an animal not only susceptible to spotted fever but also the only animal which is a host to all three stages of the tick. Not only this but the disease is unusually persistent in rabbits, and unlike the Columbian ground squirrels and other mammals susceptible to the disease that find shelter in holes and burrows, jack rabbits, no matter how sick, are always above ground and exposed to tick bites. Hence it seems likely that, providing the disease exists in nature in any given locality, if there is a coincident increase in the abundance of rabbits and ticks, then a corresponding increase in the percentage of infected ticks become probable. The occurrence of the fever fol-

lowing a parallel increase in both rabbits and ticks therefore become of interest and all the facts concerning conditions in eastern Montana seem to indicate a close relationship. The data are entirely circumstantial, however, and there is no proof. If the idea herein stated proves to have any basis in fact, however, the occurrence of the disease under certain conditions could be controlled by keeping rabbits at a point of minimum abundance instead of attempting to rid the country of ticks, a well nigh impossible task under strictly prairie conditions. It can only be hoped that the future will furnish an opportunity to carry these studies further and that some facts of a definite and reliable nature will be forthcoming.

Dr. S. B. Wolbach in a paper contained in this report presents important and suggestive information concerning the pathology of Rocky Mountain spotted fever in rabbits, and his data are of interest in connection with the possibilities suggested above.

Cottontail Rabbits. There is some reason to believe that these rabbits are more efficient tick hosts than our results have indicated. In the short preliminary survey in 1915, 111 seed ticks were secured from a cottontail but unfortunately only 22 were determined. These were all spotted fever ticks, however. Of the 8 rabbits examined in 1916 but 2 were infested (larvae and nymphs) while of 9 examined in 1917 but one was infested (female).

Porcupines. Several of these animals examined under prairie conditions late in 1916 were infested with adult ticks. The likelihood that when abundant they might be important adult hosts was strengthened by the statement of several ranchers and by the Musselshell studies during which a seasonal average of 6.8 adults per animal was obtained while in one instance 20 were secured from one animal.

Tabulation of Results of Examination of Wild Mammals for Adult Ticks

HOST	Number Examined	Number Infested	Males	Females	Total	Average per Animal	Per Cent Infestation
Jack Rabbits	7	5	11	2	13	1.86	71.43
Porcupines	5	5	23	11	34	6.80	100.00
Cottontail Rabbits....	9	1	0	1	1	.11	11.11

Domestic Animals as Hosts of Adult Ticks

Though the importance of jack rabbits and porcupines as hosts of adult ticks makes it apparent that the occurrence of ticks in many sections of eastern Montana is not dependent on the presence of domestic animals, yet there is strong reason to believe that the presence of great numbers of ticks is unlikely without their intervention. The Musselshell studies fully supported, therefore, previous studies pointing to the importance of domestic animals as a vital factor in maintaining conditions favorable to the occurrence of Rocky Mountain spotted fever.

Table 2. Tabulation of the Results of Examination of Domestic Animals

HOST	Number Examined			Male	Female	Total Ticks	Per Cent Infested	Average Per Animal	Number of Fem Engorged
		Number Infested							
Horses	138	107	1137	1036	2173	77.54	15.75	28	
Cattle	53	41	298	343	641	77.36	12.09	5	
Pigs	6	6	104	65	169	100.00	28.17	0	
Dogs	21	5	2	4	6	23.23	.28	1	

Horses. The number of horses examined in 1917 was 138 of which 107 (77.54%) were infested. The average number of adults per horse was 15.75. It is interesting to compare this result secured in a rough, hilly, wooded country with the result on the prairie in 1916 where the average infestation per horse was 1.44 and that for jack rabbits 1.87.

The following table has been compiled to indicate that the horse is the most efficient host of adult ticks among the domestic animals studied.

Table 3

HOST	Number of Females Secured	Number Showing Some Signs of Engorgement	Per Cent Showing Some Signs of Engorgement	Females over .5 Engorged		Females .8 to Fully Engorged	
				Number	Per Cent	Number	Per Cent
Horses	1036	771	74.42	40	3.86	.29	28
Cattle	343	209	60.93	6	1.75	.11	1
Pigs	65	16	24.61	0	.....	....	0

In the coulees previously mentioned as extending back into the hills from the main valleys the highest infestation of domestic animals was found. For example, 403 ticks were secured from a horse examined 13 times between April 10th and June 15th, yet these records comprised only ticks taken from beneath the jaws and between the fore legs, so that the actual total of infesting ticks would have been much greater.

On a homestead south of Elso on which a case of the fever occurred shortly after the middle of June, 97 ticks were removed from a horse as late as the 29th of that month. Earlier in the season the owner picked the ticks from his horse twice each day.

Much to the writer's surprise numerous ticks were found in the tails and beneath the fetlock of horses and both locations seemed to be very favorable for the complete engorgement of females.

Cattle. At Powderville an interesting condition was found concerning cattle. In 1916 only female ticks were secured and these few in number. Not only that but it is very positively stated by residents that ticks were only rarely seen on cattle. Even in the year 1915 when ticks were remarkably abundant there I could only get a report of a single tick, which was taken from a milk cow. In 1917, however, hundreds of ticks were sent in as taken from milk cows in a certain small specialized area. Subsequent inquiries in person failed to reveal similar conditions on any other ranch or homestead in the neighborhood.

In the hill country about Musselshell cattle were found to be an important host. Fifty cows were examined and 41 found infested (77.36%). The average per cow was 12.09. Table 3 indicates cattle to be less efficient hosts than horses. The high individual record for a single cow was 123, of which almost 50 were attached on the end 3 inches of the tail. The favorite places of attachment on cows were the dewlap, brisket, and occasionally the tail. May was by far the month of greatest importance for cattle as tick hosts.

Pigs. Though pigs have not generally been considered to be of importance as tick hosts, certain results in 1917 at least showed they may sometimes carry a considerable

number of ticks. Six pigs were examined that were running loose in a badly infested coulee. A total of 169 ticks were secured, 104 males and 65 females. Of the females but sixteen showed any signs of engorgement (24.61%) (Compare with 74.42% on horses and 60.93% on cattle). None of the females, however, were more than .2 engorged. Two pigs examined on May 1st had respectively 76 and 49 ticks. The ticks were found principally on undersides of the legs and to some extent on the flanks and belly and a few on the back. The owner of the pigs stated that in 1916, when ticks were more abundant, the pig's bellies were covered with them.

Sheep. Unfortunately opportunities for observations on sheep were not presented in 1917. In the prairie country north of the Musselshell River, however, reports and observations indicated that areas that had been used as sheep ranges were those most heavily infested with ticks. Too much of the evidence was hearsay, however, to place great reliance on it.

Relation of Character of Country to Tick Abundance

The interpretation of tick conditions in eastern Montana involves an accurate knowledge of the effect which character of the ground and the floral setting has on the abundance of ticks and the reasons therefor. Other factors being favorable, the abundance of ticks depends, to a great extent, on the character of the ground, whether rocky or not, and upon the nature of the vegetation. It is these factors which mainly determine not only **only** the species of tick hosts that are present but also the **relative** abundance of species. In a prairie country one would expect to find in abundance only animals for which such a habitat is suitable, e. g., jack rabbits, while species such as the chipmunk for which conditions are not so favorable are never likely to become an important factor in tick abundance, except under such conditions as previously noted as existing in the u-shaped bends of the rivers. In such places non-typical prairie conditions existed. Again the fauna in the hill country at Musselshell differed from that of the prairie country mainly in the relative abundance of species, unfavorable conditions reducing the abundance of some and

favorable conditions increasing that of others. Furthermore, while the distribution of host species in strictly prairie country was found to be general (with unimportant exceptions) in the hill country at Musselshell it was much more restricted because of the greater variation in topography and vegetation creating localized favorable conditions for certain host animals. Thus, in a general way, there resulted in a corresponding distribution of ticks in each type of country. In the hill country ticks in abundance were restricted to the rocky slopes before noted and to the coulees. In these places, because of favorable conditions, there occurred the greatest abundance of hosts of immature ticks, namely, pack rats, deer mice, chipmunks and cotton-tail rabbits. Field mice, though occasionally found there, were not numerous enough to be an important factor and their presence in large numbers was confined to occasional localities where entirely different conditions existed.

Periodical Tick Abundance

One of the most interesting as well as important observations made in the eastern section of the state was that in most regions ticks were unusually abundant only during occasional seasons or possibly in some places during two successive seasons. Between such years of abundance was an interval of several years. In every instance which the writer has been able to investigate, cases of fever in any locality have occurred in the years of unusual abundance. During the intervals of scarcity, in prairie country at least, ticks may be very difficult to secure. Occasional areas were found, however, within the limits of which ticks may be abundant either every season or at more frequent intervals than stated above. Most of these areas were of quite limited extent, even less than 100 acres and within them the conditions are much different than those of the surrounding country and favored the unusual abundance of tick hosts.

A knowledge of the factors that determine the periods of tick abundance and scarcity is very essential to a full understanding of the conditions which govern the occurrence of Rocky Mountain spotted fever in eastern Montana.

Data Relating to Life History and Seasonal Occurrence of Ticks

At Musselshell adult ticks appeared early in April, having been held back somewhat by prolonged cold weather in March. They were present in greatest abundance during May and the first half of June, after which there was an abrupt decline, though considerable numbers were found even in August.

Larval ticks were first taken on May 21, and nymphs on April 5. Both were still abundant when operations ceased on August 25th. Seeds and nymphs both became numerous in June. The former were most abundant later in the season, however. The latter were present throughout the spring but it was not till June that they became numerous.

Records for the preoviposition period of the female varied from 84 days for ticks taken April 19 to 39 days for ticks taken on June 11. Premolting records of engorged nymphs varied from 72 days for ticks taken on April 28 to 36 days for one taken on June 11.

Work Outside Musselshell County in 1917

During trips and through other agencies information concerning conditions and host animals were secured from parts of Meagher, Fergus, Rosebud, Big Horn, Yellowstone, Custer, and Stillwater counties. The following small animals were examined from these localities: porcupines, 1; chipmunks, 2; deer mice, 11; jumping mice, 9; prairie dogs, 45; cottontail rabbits, 2; jack rabbits, 4; ground squirrels, 5; weasels, 2; pocket gophers, 2. The most important information from these examinations was the presence of 97 fully engorged seeds of the spotted fever tick taken from a Richardson ground squirrel in Meagher county.

Examination of Longevity Experiments

The longevity experiments at Powderville, noted as started in the last report of this Board (page 55), were examined twice during the season of 1917 and once in 1918. In 1917 the examinations showed larvae, nymphs, and adults alive in all the cages and tubes. In 1918 only adult

ticks were found alive and only those in longevity tubes; all confined in cages under conditions much more natural were dead.

Comparison of Tick Conditions in the Bitter Root Valley and in Eastern Montana

A comparison of tick conditions in the Bitter Root Valley and in eastern Montana is suggestive of the great diversity of the tick problem and the extent of knowledge necessary to interpret conditions in widely separated regions. In the former a comparatively small area is concerned and due to the seriousness of conditions intensive control operations are necessary; the country is essentially of two types, thus limiting the variety of conditions to be dealt with; the Columbian ground squirrel is considered to be the only small mammal of sufficient importance to be combatted as a host of immature ticks; it is believed that small mammals may be neglected as hosts of adult ticks and that domestic animals are the only hosts of the latter that need be considered in control work. In eastern Montana the territory in which infections have occurred is hundreds of times more extensive (including most of the counties east of the mountains and south of the Missouri River); the variation in faunal and floral conditions and in types of agricultural pursuits that affect the tick problem is very great, and call for an intimate, first hand knowledge of how each change of conditions affects the tick situation; in some regions conditions are such that vast areas present the same set of conditions with which to deal, while in others they are so diverse that each holding of land presents its own special problems. Instead of the need of controlling one small and easily attacked animal (as the Columbian ground squirrel in the Bitter Root) a considerable number of important hosts of the immature ticks occur, none of them easy to control and the species and their habits varying in different localities; mice (held to be of no importance in the Bitter Root) are one of the most important hosts of larvae and nymphs; adult ticks are not confined to domestic animals but the jack rabbit is a very important host, while porcupines are of interest locally.

To further show the differences that exist in different regions and that knowledge of one locality may be almost useless in another, the habits of adults in attaching to domestic animals may be noted. In the Bitter Root the ticks on horses are essentially confined to the under side of the jaw and between the fore and hind legs, while on cattle they are found along the back. In eastern Montana ticks on horses are found mainly in the places above noted but also to a considerable extent in the tail and under the fetlocks, and on cattle they occur on the dewlaps, in the tail and occasionally on the udder (I have never found them on the back).

This comparison of tick conditions and habits could be greatly prolonged but the points given sufficiently emphasize the facts that a real knowledge of the Rocky Mountain spotted fever tick can only be gained by studies in many localities and under varying conditions and that the more knowledge of this kind we have the more intelligently the situation can be handled.

The Need of Further Investigation

The investigations of tick conditions in eastern Montana, the results of which have been briefly summarized in this and the previous report, had reached a point, at the conclusion of the work in 1917, at which it was felt that valuable results had been secured and direct lines of study were indicated. Because of the necessity of transferring operations to the Bitter Root Valley these could not be followed up but it is to be hoped that the opportunity may present itself from time to time to secure further information. Points which is particularly desirable to investigate are: factors governing the periodical abundance of ticks; the relation of rabbits to the occurrence of the fever; tick conditions in regions where ground squirrels occur (all studies have thus far been in localities where there were no ground squirrels); and host relationships of the tick and factors governing the occurrence of the fever in Carbon County (cases of fever occur in this locality almost every year and a comparison of conditions with those in other localities where cases of the disease are less frequent should yield important information).

ROCKY MOUNTAIN SPOTTED FEVER, PATHOLOGY AND ETIOLOGY; PROGRESS

S. B. Wolbach, Associate Professor of Pathology and Bacteriology, Harvard University Medical School, Boston.

In the Second Biennial Report of the Montana State Board of Entomology, I reported the finding of a minute parasite in laboratory animals infected with Rocky Mountain spotted fever and in ticks capable of transmitting the disease. This parasite was found in lesions which are characteristic of the disease in experimental animals. In infected ticks the parasite occurs in enormous numbers and its abundant presence in the salivary glands is indicative of transmission by this route. In the spring of 1917 I visited Montana for the purpose of obtaining human material and other strains of the disease. Material from three human cases was obtained and from one of these cases a new strain of the virus which has since been maintained in the laboratories of the Harvard Medical School.

The results of these investigations have been reported in brief in a third preliminary report: *Journal of Medical Research*, Vol. XXXII, No. 3, January 1918. Material from two other human cases has been secured, one case from Dr. W. T. Thornton of Missoula and one case through the kindness of Dr. R. A. Lambert who performed the post mortem on the body of a laboratory technician who became accidentally infected and died after a characteristic course of the disease. The results of the study of these five human cases have completely confirmed the conclusions based upon the study of animals and has enabled me to define Rocky Mountain spotted fever as a specific infectious endangitis of the peripheral blood vessels. A very striking feature of the disease is its exact duplication in animals and there probably is no other human disease so perfectly reproduced in animals irrespective of the mode of inoculation, whether by injection of blood from an infected animal or through the bite of an infected tick.

The blood vessels, arteries and veins of the skin of all parts of the body and in man of the genitalia are subject to the localization of the parasite. It is not the purpose of this report to present a complete description of the pathology which will shortly appear elsewhere in a more extensive report. The lesion is essentially a proliferative leison accompanied by degenerative changes in the blood vessel walls which result in thrombosis and often hemorrhage. The vessels of the internal organs practically escape and only very rare and insignificant lesions have been found. The extreme hyperesthesia in some cases is explained by the involvement of nerves in the inflammatory process which occurs in proximity to blood vessels. The distribution of the parasite in human lesions is identical with that in animals, namely in endothelial cells and in smooth muscle cells of vessels walls. In two cases there were lesions of blood vessels of the skeletal muscles to a degree warranting more careful examination of this tissue when opportunity offers; but in man as in monkeys, guinea pigs and rabbits, the tissue changes are practically limited to the superficial blood vessels and the sequences thereof in the skin and genitalia.

During the summer and autumn of 1917 an extensive series of experiments were completed, designed to throw light on the nature of the parasite and its morphology in ticks. As was stated in the first report, parasites are easily found if careful attention be given to perfection of technique. In making smear preparations it is necessary to secure thin films of the organs, teased apart rather than crushed. These films are fixed in absolute alcohol from 10 to 15 minutes, dried and stained with Giemsa's stain. In similarly teased preparations which are not permitted to dry, these parasites may be observed with the dark field illumination. The method of their demonstration in sections is as follows:

(1) Perfect fixation in Zenker's fixative saturated with corrosive sublimate. For ticks it is best to omit the acetic acid.

(2) Paraffine embedding. Sections should not be over four microns thick to ensure good staining with Giemsa's stain. After treatment with iodine for the re-

moval of sublimate deposits, the sections should be treated for ten minutes in a half per cent solution of sodium hyposulphite which must be removed by thorough washing and a final change of distilled water.

(3) Stain twelve to eighteen hours, changing the solution twice in the first hour, in the following:

Distilled water.....	100 c. c.
1/2% Sodium Carbonate.....	4 drops
Reagent Methyl alcohol.....	3 c. c.
Giemsa's stain	60 drops

(4) Without washing in water differentiate in 95% alcohol until the excess of stain is removed. Dehydrate quickly, clear in xylol or benzol and mount in oil of cedar wood.

Formula used for Giemsa's stain:

Azur II Eosin.....	3.0
Azur II	0.8
Reagent Glycerine	125.0
Reagent Methyl alcohol	375.0

Approximately two hundred ticks have been studied by the combined smear and section technique and these ticks may be divided into the following groups: (1) Ticks fed upon infected animals and subsequently proved to be infective. (2) Adult ticks proved to be non-infective by feeding on normal animals. (3) Wild adult ticks including partially engorged ticks from live stock and unfed adult ticks obtained by dragging. (4) Nymphs from uninfected strains fed upon infected guinea pigs and proved to be infective. (5) Nymphs fed upon normal guinea pigs and proved to be non-infective. In the course of the experiments a substantial contribution to the transmission of the disease by the tick has accumulated. The laborious nature of the experiments was necessary because of the impossibility of cultivating the parasite.

In the examination of these ticks in no instance was the parasite found in proved non-infective ticks or in nymphs from a proved non-infective source fed upon normal guinea pigs. In every instance the parasites were found in proved infective ticks. In a very few instances it was impossible to infect ticks by feeding on infected pigs and in these cases where the tick did not transmit the disease, the parasites could not be found. The results prove

that this parasite is inseparable from ticks capable of transmitting the disease.

The parasite as found in sections of ticks, exhibits the following forms: (1) a lanceolate paired form similar to those seen in mammals. (2) A smaller more slender rod shaped form. (3) A minute oval-coccoid form just within the limits of vision characteristically packed within nuclei of epithelial cells and in muscle cells of the intestinal tract. In smear preparations these various forms can be identified and in two experiments where infected nymphs were examined each day after feeding a certain sequence in the morphological types occurred which is of significance in tending to the conclusion that the parasite is not an ordinary bacterium and that it probably represents a new type of microorganism. Apparently only the larger lanceolate type is to be found in ticks which have been kept for several months.

This parasite was unquestionably seen by Ricketts in infected animals and in human cases. He was led to erroneous conclusions by the confusion with this organism of certain small bacteria found in normal ticks. In the course of the present research, bacteria of various morphological types have been found frequently in wild ticks and in the ova of wild ticks. One bacterium often present because of its small size can be mistaken in casual observation for the larger form of the spotted fever organism.

Although the parasite has not been cultivated in spite of a most extensive series of experiments, its relationship to Rocky Mountain spotted fever must be accepted as proved because of its constant occurrence in the specific lesions in man and laboratory animals and because of its inseparability from infective ticks. Indeed, it may be maintained that the tick experiments fulfill the conditions of proof furnished by the cultivation of specific microorganisms in test tubes.

An attempt has been made to determine the duration of infectivity of the tick. Ticks, infected as nymphs in July 1917, proved to be infective for guinea pigs December, 1918, a period of seventeen months which is approximately the maximum life period of an unfed adult. The infectivity of eggs from infected females, first determined by Ricketts, has been confirmed. At the suggestion of Dr.

R. R. Parker, a study of the susceptibility of rabbits has been made with the help of Dr. N. C. Foot. Although Gomez in 1909 stated that rabbits could be infected, his results were not accepted by Ricketts who reported unsuccessful attempts to infect rabbits by intravenous inoculation. We have succeeded in infecting rabbits by the subcutaneous injection of blood from infected guinea pigs and through the bite of infected ticks. The latter is of considerable importance as it naturally has a bearing on what may occur in nature. The series of rabbit experiments is still small, twenty, and a considerable variation in the susceptibility in different rabbits has been noted. Further work should be done on wild rabbits rather than with the mixed strains, presented in the laboratory of domestic breed. The presence of the disease in our rabbits was proved by a characteristic temperature reaction, the appearance of anatomical lesions and finally by the demonstration of the microscopic lesions containing parasites in the blood vessels of the skin and genitalia. The mortality of the disease is markedly lower in rabbits than in guinea pigs. Rabbits which recover from the disease are immune to subsequent infection and an obvious field for research is the possibility of chronic infection in rabbits which has been suggested by some of our experiments. A few experiments have been made with the off-springs of immune rabbits. Present results indicate that there is no transmission of immunity to the young of immune parents. The behaviour of the virus in rabbits needs further study as we were unable to maintain the strain indefinitely in rabbits, there being a gradual decline in infectivity with repeated passage. It would seem highly desirable to have an extensive study made of Rocky Mountain spotted fever in both types of rabbits common to infected territories in view of the fact that the rabbit may act as a host to all stages of the ticks. There is a possibility that some light may be thrown upon the variation in virulence of the disease in different localities and also upon the variation in incidence of the disease from year to year.

A short series of experiments have been made upon the curative value of immune serum in the experimental disease and while we have in the main confirmed the results of Ricketts, it does not seem probable that a highly

potent immune serum can be obtained from the smaller laboratory animals.

The following conclusions have been arrived at. The specific lesions of Rocky Mountain spotted fever are practically restricted to the blood vessels of the skin and genitalia. The reaction is a characteristic one, an endangitis characterized by endothelial cell proliferation, local necrosis of endothelium and smooth muscle and thrombosis. The cause of the disease is the minute parasite described. The parasite in all probability represents a new type of microorganism. A complicated life cycle has been excluded and the organism would seem to be more closely related to bacteria rather than to protozoa.

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